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ORIGINAL ARTICLES.

I.—On a Remarkable Ichthyodorulite from the Carboniferous Series, Gascoyne, Western Australia.

By Henry Woodward, LL.D., F.R.S., F.G.S., etc.

(PLATE I.)

TWO years ago, Mr. Robert H. Scott, F.R.S., Secretary to the Council of the Meteorological Office, kindly sent me a letter from the Rev. J. G. Nicolay of Fremantle, Western Australia, accompanied by a photograph of a fossil, the original of which had been found by Mr. Davis "in the valley of the Arthur River, an affluent of the Gascoyne." [1]

I readily identified the fossil photographed as the impression of a fish-spine, similar in form, but more highly curved than those discovered in the Coal-measures of Arkansas, Indiana and Illinois, originally described by Prof. Leidy as a fish-jaw, and named by him *Edestus vorax* in 1855, and later as a fish-spine by MM. Newberry and Worthen (Geological Survey of Illinois, 1870, vol. iv. pp. 350–353, pl. i.). Having expressed a wish to see the fossil itself, Mr. Scott at once wrote to his sister, Lady Barker, wife of the Governor of Western Australia, at Perth, who most kindly interested herself to obtain the loan of it from Mr. Nicolay. After a protracted correspondence, Mr. Edward T. Hardman, F.G.S., of the Government Geological Survey of Ireland (who was at that time engaged upon a Survey of the Kimberley District, Western Australia), was, upon his return to England, entrusted with the charge of this unique specimen, which is now in my hands.

The fossil (which is represented in our Plate I. of the natural size) consists of the half of a heavy clay-ironstone nodule, having the intaglio impression of a curved organism; the relievo half of the nodule was not found. It was picked up by Mr. Davis "in the valley of the Arthur River, an affluent of the Gascoyne from the right, *i.e.* the north, above the confluence of the Lyons with the Gascoyne, and about 130 miles in direct distance from the sea; both rivers have, as I am informed, cut their channels through a flat-topped range, which stretches beyond the Lyons to the north-west, and on the top of which are found fossils very numerous, bedded in limestone, among which a striated-winged Spirifer" (probably *Spirifer vespertilio*, G. Sby.?) "is prominent. It may be assumed that the limestone bed is superior in position to that of the ferrugi-

[1] Spelt, in some maps, "Gascoigne."

nous concretionary sandstone" (clay-ironstone) "in which the fossil was bedded" (extract from Rev. J. G. Nicolay's letter to Lady Barker, Government House, Perth, W.A., 13th July, 1883.)

A carefully-prepared cast from the natural mould of the fossil shows us in relief the curved outline of what may be estimated as about three-fourths of the entire spine of a fish closely related to *Edestus Heinrichsii*, of Newberry and Worthen, from the Coal-measures of Belleville, Illinois, but of much smaller dimensions, less robust, and more highly curved than the American species.

We see in the Australian fossil 14 perfect flattened lancet-shaped denticles, the cutting edges of which are crenulated along each border (like the teeth of many of the Plagiostomous fishes) the denticles being closely set along the outer curve of the spine, and touching each other at their broadest expansion. They increase gradually in size from one extremity of the fossil to the other. The smallest denticle measures 3 lines in breadth, and 7 lines in length; the largest is 5 lines broad, and 11 lines in height. There is evidence of the bases of one more denticle at the smallest end, and two more at the largest end of the spine. The outer curve (which forms the segment of a nearly true circle of $4\frac{1}{2}$in. diameter) measures around the points of the denticles $6\frac{3}{4}$in., and on the inner margin of the spine (following the curve in each case) $3\frac{1}{4}$ in. The breadth of the spine with its denticle at the broadest end is 16 lines; and at the narrowest end 11 lines. The character of the American *Edestus* is that the shaft of the spine is segmented throughout, and breaks up into curved portions, each bearing a denticle; these segments overlap to such a degree that the bases of the denticles are seen to curve beneath each other, forming a series of raised imbricated ridges on the sides of the spine, each curved ridge leading up to the base of a denticle, as admirably shown by Prof. Leidy in his original paper. The substance of the shaft of the spine of the Australian fossil must have been much less massive than the American form, but was evidently, like it, highly enamelled along its outer convex toothed border, the hollows of the cast being all finely glazed.

In the Proceedings Acad. Nat. Sci. of Philadelphia, vol. vii. Oct. 30, 1855, p. 414, Dr. Joseph Leidy gives the name *Edestus vorax*, to a new genus of fishes, founded on a supposed fragment of a jaw with portions of four teeth. In the Journal of the Acad. Sci. of Philadelphia, Nov., 1856, 2nd ser. vol. iii. p. 159, Dr. Leidy describes the specimen more fully, and figures it on plate xv. "The fragment of jaw is six inches in length; and it measures three inches in depth from the dental border. The sides are symmetrical, and slope divergently from the latter position towards the base, which is convex and moderately keeled in the median line. At the dental border the jaw is about seven-eighths of an inch in thickness, and at the thickest part of its base measures one inch and four-fifths. Longitudinally the base of the jaw is slightly concave and furrowed. The surface of the bone is covered with fine vermicular, reticulating, broken ridges, assuming a striking resemblance to Arabic writing. The most remarkable peculiarity

of the jaw is its segmented character; and of the segments the fossil retains two very nearly perfect ones with portions of two others. Each segment in outline forms an irregular pentahedron; and each possesses a single coössified tooth, whose broad surfaces abruptly increase the acclivity of the sides of the jaw."

This specimen is most probably from the Carboniferous series, and was found at Frozen Rock, Arkansas River, 20 miles below Fort Gibson, in the Indian Territory.

Prof. J. S. Newberry describes a much smaller specimen, under the name of *Edestus minor*, in the Geol. Surv. of Illinois, vol. ii. 1866, p. 84, and gives a figure on plate iv. fig. 24. This figure represents one tooth only, 10 lines long, and $5\frac{1}{2}$ lines wide at base, and 3 lines thick, set saddle-like upon the edge of a flat, bony jaw. This specimen was obtained from the Coal Measures, Posey County, Indiana. In vol. iv. of the same work, at p. 350, Newberry and Worthen describe and figure, pl. i. fig. 1*a*, 1*b*, another specimen under the name of *Edestus Heinrichsii*, from the Coal Measures of Belleville, Illinois. The following is the description given by Messrs. Newberry and Worthen of *Edestus Heinrichsii*, N. & W., 1870:[1]—"Spine robust, one foot or more in length, by two and a half

Fig. 1.—Part of the spine of *Edestus* sp? (*E. Heinrichsii*?), Coal M., Indiana.

inches wide, and one and a quarter inch thick, composed of dense, bony tissue, symmetrically flattened, with an ovoid section below; lenticular above; one margin nearly straight, the other gently arched; the basal end irregularly rounded off; the arched border set with nine large, triangular, flattened, doubly crenulated, enamelled denticles, each about an inch in height, the upper half of the straight line forming a sharp cutting edge. The denticles of the arched border are broadly triangular in outline, rising perpendicularly from the curved edge on which they rest, each three-quarters of an inch in height, by one and a quarter inch in breadth, compressed laterally, with crenulated cutting edges. They are contiguously placed, and each is embraced by the acute

[1] Geological Survey of Illinois, vol. iv. Geology and Palæontology, 4to, Illinois, 1870, pp. 350-353, pl. i. figs. 1*a* and 1*b*. Some confusion exists in the references to the figures here; for of the two species drawn on the plate, the one named *E. Heinrichsii* agrees best with Leidy's original figure; whilst the one named *E. vorax*, which agrees with our woodcut (*supra*), has much larger denticles.

prolongations of the enamelled base of the superior denticle, which reaches back to its middle point. The spine is segmented throughout, each segment bearing a denticle; the segments overlapping to such a degree that the one bearing the superior denticle reaches two-thirds of the distance from the summit to the base of the spine."

A comparison of the Australian fossil spine with the American species of *Edestus* (excellent casts of both of which are in the British Museum, Natural History) has convinced me that its true place is in or near to Leidy's genus. The denticles are placed on the *convex* edge of the spine, a peculiar feature in the genus *Edestus*, nearly all the spines of fossil plagiostomous fishes being denticulated along the inner *concave* curved edge.[1] The imbricated curved lines passing from each denticle obliquely across the shaft of the spine are also seen in both, and are quite peculiar to *Edestus*.

Prof. Newberry has clearly pointed out the objections to the theory, at first suggested by Prof. Leidy, that *Edestus* was part of the mandible of a plagiostomous fish. He mentions that "the jaws of sharks are always cartilaginous, holding the bony and enamelled teeth only by ligamentous attachments, so that in a fossil state the jaws have usually disappeared, and the teeth are scattered, whereas in *Edestus* we have a dense bone to which the tooth-like denticles are united by a firm bony anchylosis." Again, "The form of the fossil is wholly unlike that of any jaw of fish, reptile, or mammal known, being rounded below, and terminating in an acute point, smooth, even polished, and evidently never having been covered by integument."

In comparing the Australian fossil with various specimens in the collection, Mr. William Davies drew my attention to the similarity in arrangement of the teeth of *Janassa bituminosa*, from the Permian of Durham; in one specimen of which six teeth with prolonged and highly-curved bases may be seen united; but these teeth differ in arrangement from the denticles of *Edestus* in being placed broad-wise behind each other, not edge-to-edge in a row, as in *Edestus*.

The only structure amongst fossil fishes strikingly analogous to *Edestus* is to be found in the pectoral fins of the genus named by Agassiz *Ptychodus*, from the Chalk of Sussex, and since described by Prof. E. D. Cope from the Chalk of Kansas, under the name of *Pelecopterus*.

Professor Cope writes:—"The entire pectoral fin, so far as is known, is devoted to the construction of a powerful spine. This follows from the fact that the spine is supported by all the basilar bones. Six of the latter articulate in the fossæ of the groove of the scapula. They are flat, contracted at the middle, and expanded at the extremities. In front of these are two others of a short, thick, cylindric form, one applied to the superior, the other to the inferior facets of the scapula above mentioned, while the tuberosity rises pedestal-like between them. This structure gives a slight hinge-movement like the opening of the blade of a knife, and

[1] In *Pleuracanthus* the spines are barbed on *both edges*, and so also are the spines of the Sting-rays.

entirely unlike the rotary hinge-movement characteristic of the pectoral spines of Siluroid fishes."

"The spine is composed of parallel rods in close apposition. The anterior edge being oblique, the extremities of the rods terminate successively at the border, which is trenchant, constituting the offensive part of the spine. The edge is hardened, and the adjacent parts of the spine thickened, and in some cases roughened by a deposit of a hard substance resembling enamel. It is either straight or regularly undulate or serrate, with recurved, acute, tooth-like processes. The smaller species exhibit the serrate character, the larger the regular border. In either case a most formidable weapon is indicated, not less admirable than those already described from Palæozoic rocks. *There is a considerable resemblance between the serrate type and the spines of the Carboniferous genus Edestus,* in which the teeth are more developed and denticulate." (E. D. Cope. Report of the United States Geological Survey of the Territories. F. V. Hayden, U.S. Geologist-in-charge, vol. ii. p. 244B. 4to. Washington, 1875.) (See Woodcut, *infra*, Fig. 4.)

Fig. 2. Fig. 3. Fig. 4. Fig. 5.

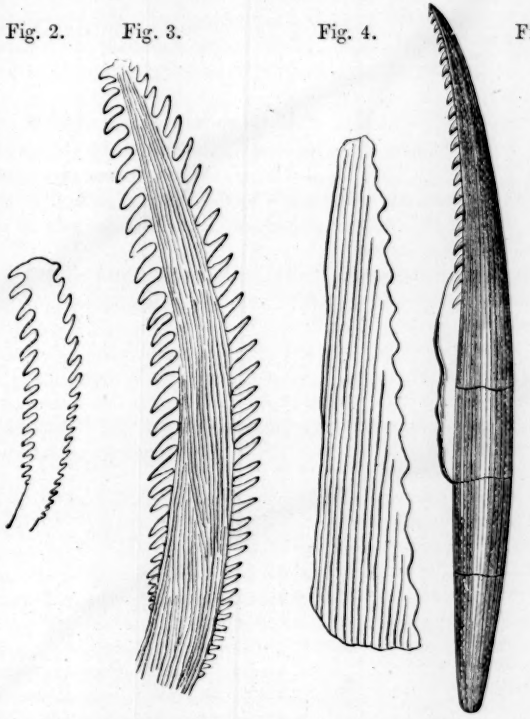

Fig. 2. Pectoral Spine of *Aspredo lævis ;* (recent) *Surinam.*
„ 3. „ „ *Doras,* sp. „ S. America.
„ 4. „ „ *Pelecopterus,* sp.. Chalk, Sussex.
„ 5. Dorsal Spine of *Hybodus,* Wealden, Sussex.

Amongst recent plagiostomous fishes I do not find any one species with spines at all comparable in the least degree with the type of *Edestus*. If it be permissible to interpret the Australian fossil to be the impression of the spine of the pectoral fin of an *Edestus*-like fish, there are numerous examples of living Siluroid fishes with powerful pectoral fin-spines, some of which at least have denticles upon the outer as well as the inner edge of the spine, although none are so highly curved as the Gascoyne fossil. *Arius rita*, of the river Ganges, has denticles on *both edges* of its pectoral spines; so also has *Aspredo lævis* (Woodcut, p. 5, Fig. 2), from Surinam; *Synodontis omias*, and *Auchenaspis falcarius*, from West Africa; *Arius falcarius*, Formosa; and *Silurus glanis*, from Lake Derkos; *Doras*, sp., from South America (Woodcut, p. 5, Fig. 3), and many others.

It is difficult to imagine any fish with a pectoral spine curved to so great a degree as is this Australian ichthyodorulite, but on the other hand it seems improbable that it was a median dorsal defence.

To quote again from Prof. Newberry:—"The segmented structure of the fossil is its most marked and anomalous feature, but one equally so, whether it be considered spine or jaw, and for which no parallel suggests itself. It is undoubtedly to this structure that we must ascribe the absence of a large medullary cavity, as each segment seems to have been nourished somewhat independently of its fellows.

"It is also evident that this spine was implanted in the integument at a low angle, and that an investing skin or other nutrient tissue covered fully half its surface, on the lower portion reaching up to the enamelled bases of the denticles. This is the relative position of the defensive spines of Rays, to which an analogy is suggested by this character.

"In some plagiostomous fishes, a bone is found quite buried in the integuments of the back, and which is a rudimentary representative of a posterior dorsal fin; it is, therefore, not impossible that we have in the fossil before us, a higher development and special modification of that organ." (Newberry and Worthen, *op. cit.* p. 352.)

Referring again to the valuable and suggestive memoir by Prof. E. D. Cope on *Pelecopterus* quoted above (p. 4), I cannot but think that it affords the most probable explanation of the anomalous structure in *Edestus*.

"The entire pectoral fin," says Cope, "so far as it is known, is devoted to the construction of a powerful spine." "The spine is composed of parallel rods in close apposition. The anterior edge, being oblique, the extremities of the rods terminate successively at the border, which is trenchant, constituting the offensive part of the spine."

It appears to me to be only necessary that the 'parallel rods' composing the spine of *Pelecopterus* should be bent into curves, corresponding to the segmentation seen in *Edestus*, and we at once have a solution of the peculiar structure in the latter.

If this interpretation be accepted, then *Edestus* must be deemed to be, like *Pelecopterus*, a modified pectoral fin-spine, composed of a

number of parallel rods in close apposition, but highly curved in the former; the anterior edge in both being oblique, the extremities of the rods terminate at the border, constituting with its dentated edge the offensive part of the spine.

Without attempting more on the present occasion than to point out the interesting analogy between the Australian fossil and the American genus *Edestus*, it seems, nevertheless, of the greatest interest to call attention to the probable nature of this organism and its geological age.

So lately as June 6th, 1883, Mr. W. H. Hudleston, F.R.S., F.G.S., communicated a paper to the Geological Society of London, "On a Collection of Fossils and of Rock-Specimens from West Australia, north of the Gascoyne River," since published in the Quart. Journ. Geol. Soc. vol. xxxix. pp. 582–595, pl. xxiii.

In this paper Mr. Hudleston mentions an earlier paper by Mr. F. T. Gregory in 1861, and a map and sections presented to the Society in 1847. "The paper and sections by Mr. Gregory must be regarded (says Mr. Hudleston) as having laid the foundation of Western Australian Geology south of the parallel of the Gascoyne river." "Mr. Forrest, the Colonial Surveyor, appears to have discovered a range, or more properly a sort of continuous outcrop trending N.N.W. for nearly 150 miles, which has yielded an interesting suite of Carboniferous fossils." A list of about 32 species is given by Mr. Hudleston, namely, 5 Corals, 2 Echinodermata, 4 Polyzoa, 8 Brachiopoda, and 2 Lamellibranchiata. It is not without interest in connection with the present discovery of a Fish-spine in this region closely related to the American *Edestus* of Leidy, that two species of *Evactinopora* are described, one of which is said to be similar to Meek and Worthen's *Evactinopora grandis* and is also, like *Edestus*, from the Carboniferous of Illinois (see Hudleston, *op. cit.*).

I have been requested to append the discoverer's name to this fossil, and as I am unwilling, in the present state of our knowledge, to make a new genus for its reception, I propose to name it *Edestus Davisii*.

EXPLANATION OF PLATE I.

FIG. 1*a*. Pectoral fin ? spine of *Edestus Davisii*, H. Woodw. (nat. size), from the Carboniferous Series of the Gascoyne District, Western Australia.

1*b*. Conjectural outline section of spine.

II.—IRISH METAMORPHIC ROCKS.

By G. H. KINAHAN, M.R.I.A., etc.

Read at British Association, Aberdeen, 1885.

THE meeting of the British Association in Montreal gave different Irish geologists facilities for examining the Archæan rocks of Canada and the States, while since then they and also American geologists have had opportunities for studying the Irish Metamorphic rocks; it may therefore be allowable to give an epitome of our knowledge in regard to the latter.

In ten localities in Ireland are found metamorphic rocks more or less similar to those of America; these localities may be classified as

follows:—1st, Boylagh and Kilmacrenan, Co. Donegal; 2nd, Tirhugh, Co. Donegal; 3rd, Erris, Co. Mayo; 4th, Slievegamp and Ox Mountain, Cos. Mayo, Sligo, and Leitrim; 5th, Charlestown district, Co. Mayo; 6th, Slievegallion or Pomeroy district, Cos. Tyrone and Derry; 7th, Cary or Ballycastle district, Co. Antrim; 8th, Yar-Connaught or West Galway; 9th, Croaghankinshella, Cos. Wicklow and Wexford; and 10th, Carnsore, Co. Wexford.

Boylagh and *Kilmacrenan.*—These are the northern baronies in the county of Donegal, across which obliquely a tract of granitic rocks extends, having outlying patches in Rossgull and Fanad, in the latter barony. In connection with the gneiss there are some remarkable peculiarities which as yet have not been explained; but as the country has still to be completely explored, it seems expedient only to say that the Americans seem to consider the gneiss and associated schists of Lackagh valley to be lithologically identical with the American rocks of Mt. Alban series (Hitchcock) or Hudson River series (Dana), as seen in the vale of the Schuyllkill river, Pennsylvania; and these American rocks they consider to be the equivalents of the English Ordovician or Lower Silurian. Immediately south of the gneissoid rocks supposed to be Laurentians, there is a long tract of rocks which lithologically are identical with some of the Ontario Laurentians, much more so than any of the gneissose rocks; they, however, have been ignored. To the main tract of gneiss in the barony of Kilmacreenan, *in any place*, either along the north-west or south-east of its limits, there are no hard boundaries to indicate an unconformability or fault boundary, as along these boundaries *the gneiss graduates into schists, and the latter into submetamorphic rocks;* to the south-east, however, the graduation is, in general, more rapid than to the north-west.

Tirhugh.—This tract is situated to the N.W. of Pettigo, in the south portion of the Co. Donegal. The rocks partake very much of the lithological characters of some of the Ontario Huronians and Laurentians, but up to the present time they have not been claimed as Irish Laurentians. In former writings I have suggested that they are probably the representatives, either of the Passage beds between the Ordovicians and the Cambrian, or of the Upper Cambrians.

Erris.—This is a portion of North-west Mayo. The gneissose rocks have no well-defined boundaries; neither has there been found in connection with them an overlying unconformable conglomerate, as has been believed by some, on account of the wording of their published descriptions. In former papers (Royal Geol. Soc. Ireland) I have suggested that these rocks are metamorphosed Cambrians, but no positive statement can be made as to their age; lithologically they are similar to the metamorphosed Cambrians of the Co. Wexford, but they are also very like some of the American Laurentians.

Slieve Gamp and Ox Mountains.—These rocks occupy a long narrow strip which extends from north-east Mayo, across Sligo into the county of Leitrim. Some of the rocks are peculiar, as they occur, similarly to the Norians of the Province of Quebec, as intrusive masses, into which a coarse foliation has been subsequently introduced. The

assemblage appears to be the north-easterly extension of the rocks of West Galway; elsewhere I have suggested that they are probably either metamorphosed Ordovicians or Upper Cambrians.

Charlestown District.—This small exposure occurs near the north-east boundary of Mayo; the rocks are more or less similar to those in Tirhugh, but so few of them are exposed that it is difficult to form an opinion as to their age; for the reasons given in a paper read before the Royal Irish Academy, I have suggested that they may be either of Upper Cambrian or Ordovician age, probably the latter. As yet they have not been claimed as Laurentians.

Slieve Gallion or Pomeroy District.—This area is principally in the Co. Tyrone, only a small portion extending into the Co. Derry. The opinions in regard to the age of the rocks have undergone sudden and extraordinary changes. First, they were mapped as of Lower Silurian age, and when I showed that this classification must be incorrect, it was again insisted on; but subsequently this opinion was suddenly ignored, and they were stated to be of Laurentian age. Lithologically many of these rocks are very similar to some of the Canadian Huronians, and if there are any Archæan rocks in Ireland, they probably occur here, as the rocks are evidently much more ancient than the Ordovician to the south, while they appear to be older than the submetamorphic rocks to the northward in the Co. Derry; however, for reasons given elsewhere, I suspect that they are metamorphosed Cambrians.

Cary or Ballycastle District.—These rocks occupy a tract at the extreme north-east of Ireland, in the Co. Antrim. They seem to be the north-east extension of the Slievegallion rocks, and to be of a similar age, having been heaved northward by the great faults of the Lough Neagh basin. As yet they appear to have escaped the general confiscation.

Yar-Connaught or West Galway.—This tract lies immediately north of Galway Bay. The age of these rocks is very apparent, they rest on a great anticlinal curve, the axis of which dips westward, thus bringing up the oldest rocks to the westward, in the hill group called Bennabeola. Some of the older rocks are lithologically identical with the Laurentians of the district of Chelsea, Province of Quebec. Yet these older rocks of Bennabeola have not been claimed as Laurentians, although the younger rocks to the southward have been — although the latter, from their fossils in the unaltered portions, appear to be the equivalents of the English Llandeilo and Bala series.

Croaghankinshella.—Here the highly altered rocks occupy a small tract at the meeting of the counties of Wicklow and Wexford, and if lithological characters are conclusive, they ought to be included among the Irish Laurentians, which up to the present has not been done. Northward they have a hard boundary; southward their margin is obscured by superficial accumulations, but eastward and westward they graduate into the rocks belonging to the upper divisions of the Irish Ordovicians.

Carnsore.—This is a small tract at the S.W. extremity of Ireland,

in the Co. Wexford. The rocks therein have not been claimed as Laurentians by Dr. Hull, although some have been so classed by Dr. Callaway. All the rocks are evidently portions of one group. To me it would appear that unquestionably they belong to the neighbouring rocks, which by their fossils are proved to be of Cambrian age.

The sole evidence for the existence of Laurentian rocks in Ireland is the lithological characters of the rocks; and if such characters are of value, they ought to be of equal value in every case. This, however, is not the case, as in many places rocks lithologically more or less similar to the American Laurentians are left out in the cold; while in other places younger rocks, whose age is indicated by their fossils, are included.

III.—The Tuffeau de Ciply shown to be chiefly of Tertiary Age.

By MM. A. Rutot and E. Van den Broeck.

WE wish briefly to state an important result, which the study of certain Tertiary and Cretaceous beds in the neighbourhood of Mons has enabled us to arrive at.

For a long time past, the beds, well known in the district just mentioned, by the name of *Tuffeau de Ciply*, have been considered by all geologists to be the equivalents of the Maestrichtien, that is to say, as belonging to the highest subdivision of the Cretaceous series of Belgium.

Now, our recent researches have convinced us that in the group of beds called the *Tuffeau de Ciply*, there have been confounded two series quite distinct from each other:

A. A lower fossiliferous series of slight thickness, extremely rich in characteristic Cretaceous species, amongst which may be mentioned specially *Thecidium papillatum* and *Belemnitella mucronata*. We propose to give to this inferior tuffeau, which appears to correspond to certain horizons of the Upper Cretaceous (Maestrichtien) of Limbourg, the name of *Tuffeau de St. Symphorien*, from the locality where it may, at present, be best observed.

B. An upper series, with fossiliferous zones, devoid of Cretaceous species,[1] but containing, on the contrary, a fauna with a Tertiary facies, including numerous forms identical with those of the *Calcaire grossier de Mons*. This series, which attains a thickness of nearly twelve metres, constitutes the type of the deposit known by the name of *Tuffeau de Ciply*. Its base is formed by a conglomerate called the *Poudingue de la Malogne*, which, in certain localities, contains numerous rolled Cretaceous forms derived from the underlying formations.

The preceding data have been derived from stratigraphical and palæontological observations, which show, furthermore, that there exists an insensible passage between the Eocene formation known as the *Calcaire grossier de Mons* and the *Tuffeau de Ciply*, by the

[1] Nevertheless, two Maestrichtian forms, *Thecidium longirostre*, Bosq., and *Argiope microscopica*, Schloth., have passed up into the Eocene *Tuffeau de Ciply*.

intervention of a deposit called the *Calcaire de Cuesmes à grands Cerithes.* On the other hand, a well-marked separation exists between the *Tuffeau de Ciply* and the underlying Cretaceous tuffeau with *Thecidium papillatum.*

Our palæontological proofs are founded on the presence of nearly a hundred species, for the most part casts or impressions, collected in the *Tuffeau de Ciply,* from its base upwards, among which species there exist only a very few Cretaceous fossils, and these rolled, evidently derived from the underlying beds, in contrast with a rich fauna having a Tertiary facies, consisting of Gasteropods, Lamellibranchs, Corals, etc., amongst which may be distinguished species either identical with those of the *Calcaire de Mons,* or nearly allied to them, associated with numerous forms probably new.

A general examination of the smaller organisms, such as Foraminifera, Polyzoa, etc., leads us to believe that their comparison with the microscopical fauna of the *Calcaire de Mons* will lead to conclusions similar to those which we have arrived at from a comparison of their molluscan fauna.

We intend shortly to publish, in the Bulletin du Musée d'histoire naturelle de Belgique, a Memoir setting forth in detail the results that we have now briefly stated, and which modify in an unexpected manner the stratigraphical position of the line of separation of the Cretaceous and Tertiary formations of Belgium.

IV.—On a Modern Ferruginous Conglomerate upon Ashby Wolds, Leicestershire.

By W. S. Gresley, F.G.S.

DURING the summer of 1885, in excavating for a small reservoir for colliery purposes at Moira, three miles west of Ashby-de-la Zouch, an interesting deposit of a kind of Limonite Iron-ore was met with, the following description of which may interest some of the readers of the Geological Magazine.

The bed occurred about five feet below the surface soil, near a small stream, at a place called "Hanging Hill" [see Geol. 1-inch Map, Quarter-Sheet No. 63, N.W.]. In thickness it hardly reached a foot, but its extent was not proved; it rested unconformably upon stiff blue clay of the Coal-measures, and was overlaid by yellowish clay, loam, sand, etc., unstratified, containing a few pebbles and other drifted matter; it was principally composed of nodules and fragments of nodules of earthy yellowish brown ironstone, of similarly formed pieces of very hard and compact light grey siliceous stone having a thin crust or shell of compact dark brown iron-ore, (probably göthite), of sandy nodular masses largely composed of limonite; of fragments and small nodules of fossiliferous hard red hæmatite generally coated with a bright red skin which is often powdery; also specimens of compact brown iron ore having a yellow ochre coating, sometimes the compact red and yellow hæmatites are associated in the same sample, the latter variety appears to form

a kind of shell to the red ore, though occasionally the two kinds exist in thin alternating bands. These hard hæmatite fragments are sometimes partially composed of quartz grains, and the concentric zones of oxidation seen upon the surface of the specimen run through the gritty parts just as they do through those devoid of the quartz grains. Other specimens observed should, I think, be termed iron-jasper rather than classed as hæmatite. The remainder of the included pebbles, etc., are chiefly those of quartzite and fine-grained hard sandstones and slaty rocks of yellow, brown, and green tints; also small fragments of coal. The size of the fragments in the deposit range from mere specks to say eight inches in length, and the whole mass is cemented together into a very hard and often compact rock by brown iron ore of a semicrystalline siliceous character. The bed is also fossiliferous, in that it contains bits of decayed vegetable detritus, amongst which well-preserved *nuts* (hazel-nuts) occur. These organic remains are not petrified, but only browned and blackened, just as we sometimes find *Lepidostrobi*, ferns, etc., occurring in a peculiar decayed and carbonised condition in certain beds of the Coal-measures.

In regard to the derivation of this conglomerate and the way in which it was probably formed, I may add that the nodular lumps of earthy iron-ore, as well as the harder limonite-crusted masses, were originally clay-ironstones, etc., of the neighbouring Coal-measures; that the fragments of hard hæmatite (which are 'burnishers') have been derived from the outcrop of the Permian breccias by which the western margin of the exposed Leicestershire Coal-field is partly overlaid [see GEOL. MAG. for 1885, p. 333], and that the quartz and other pebbles, etc., have come from the Bunter series, also found within a mile or so of the locality of this iron-ore gravel-bed. The nuts, twigs, etc., were of course buried during the deposition of the gravel, but the cementing iron-ore, which has acted chemically so much upon the mass (as evidenced by the staining of the pebbles and the alteration of the clay iron-stones and other fragments), I consider has been thrown down during a quiet period subsequent to the deposition of the stones, etc., and was most likely produced from chalybeate waters issuing from the Coal-measures close by the bed of gravel; the whole was subsequently covered over, and thus consolidation resulted.

It need scarcely be added, that the presence of hazel-nuts in the deposit proves it to be of quite recent date.

POSTSCRIPT.—The finding of a rusty iron nail of square section, in lengh $2\frac{1}{4}$ inches, which is thickly, though irregularly, encrusted with iron oxide and sandy matter, in this deposit, shows it to be of quite recent date.

I am inclined to think, from the appearance of the locality, that this iron-gravel occupies what was once the upper or shallow end of the bed of a mill-pond; at all events the character of the deposit is such as we might perhaps expect to find in such a situation.

V.—On the Graptolite Family Dichograptidæ, Lapw.

By Dr. Otto Herrmann.[1]

[Translated and Abridged by W. S. Dallas, F.L.S.]

Sub-order Rhabdophora, Allm. Group Graptolitidæ, Lapw. Family Dichograptidæ, Lapw.

Hydrosoma bilaterally developed. Branches regular, always furnished only with a single series of hydrothecæ (Monoprionidian). Hydrothecæ rectangular, touching one another, their inferior margin slightly curved. Sicula generally persistent; its free, pointed, downwardly directed end at the proximal extremity of the hydrosoma.

In 1851 M'Coy (Brit. Pal. Foss. p. 9) proposed the generic name *Didymograptus* for two-branched species with one row of cells "sometimes on the inner, sometimes on the outer side of the branches." Nearly at the same time Geinitz established his genus *Cladograptus* to include all two-armed or furcate Graptolites. These two denominations have been employed in various senses by succeeding authors, and considerable confusion has resulted. Hall[2] remarked that these genera contained at least two distinct types, and proposed to retain the name *Didymograptus* for such forms as *D. Murchisoni*, Beck, and to give that of *Cladograptus* to *Didym. divaricatus*, Hall, and its allies. His genus *Dicranograptus* applied to forms like *D. ramosus*, Hall. may be dropped.

In 1871 Hopkinson[3] separated such forms as *Didymograptus (Cladogr.) Forchhammeri* under the generic name of *Dicellograptus*. He adopted Hall's view of the nature of *Didymograptus*, abolished the name *Cladograptus* as a designation of two-branched Graptolites, and accepted Hall's name *Dicranograptus*. The two-branched Graptolites were thus divided into three genera:—

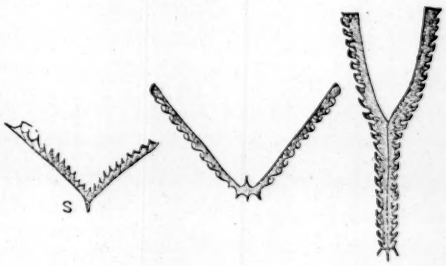

Fig. 1. *Didymograptus vacillans*, Tullberg.
„ 2. *Dicellograptus Forchhammeri*, Geinitz.
„ 3. *Dicranograptus ramosus*, Hall.

[1] Abridged from the third chapter of Dr. Herrmann's paper in the Nyt Magazin for Naturvidenskaberne, vol. xxix. pp. 124—214. (See also Geol. Mag. 1885, Dec. III. Vol. II. pp. 406 and 448.)

[2] Introduction to the Study of the Graptolites, Albany, 1868, p. 234.

[3] Geol. Mag. 1871, Vol. VIII. p. 20, Pl. I.

1. *Didymograptus*, M'Coy (belonging to Lapworth's family Dichograptidæ) with such forms as *D. Murchisoni*, Beck and *D. vacillans*, Tullb. (Woodcut, p. 13, Fig. 1).
2. *Dicellograptus*, Hopk. (of the family Dichograptidæ, Lapw.) with such forms as *D. Forchhammeri*, Gein. (Fig. 2).
3. *Dicranograptus*, Hall (of the family Dicranograptidæ, Lapw.) with such forms as *D. ramosus*, Hall (Fig. 3).

To these may be added the still somewhat problematical genus of the family Dichograptidæ:—

4. *Janograptus*, Tullb., with such forms as *Janograptus laxatus*, Tullb. (see p. 16).

The following genera are adopted by the author:—

Genus I. Didymograptus, M'Coy.

Hydrosoma bilaterally symmetrically developed, consisting of two simple branches diverging at an angle of 70°—180°. Sicula well preserved and always visible. The two primordial buds originate in the neighbourhood of the broad end of the sicula. Lower Silurian.

Species.

a. Type *Didymograptus patulus*, Hall.

1. *Didymograptus patulus* (Hall), Nich., Hopk. and Lapw., Brögger.
   Graptolithus patulus, Hall, *D. hirundo*, Salt., Nich.

Angle of divergence about 180°.

Horizons and Localities.—Quebec Group, Canada; Middle and Upper Arenig, St. Davids; Skiddaw Slates, North of England; lower part of the *Phyllograptus*-shales, Norway; *Phyllograptus*-shales, Skåne and West Gothland.

2. *Didymograptus constrictus* (Hall), Linnars., Lapw., Brögg.
   Graptolithus constrictus, Hall.

Quebec Group, Canada; Lower Graptolite shales, Skåne; *Phyllograptus*-shales, Norway.

3. *Didymograptus extensus* (Hall), Nich., Hopk., and Lapw., M'Coy, Brögg.
   Graptolithus extensus, Hall.

Quebec Group, Canada; Lower Arenig (Wales); doubtfully in the Lower Bala of Australia; Lower part of *Phyllograptus*-shales, Norway.

4. *Didymograptus euodus*, Lapw. (and Hopk.).
   D. extensus, var. *euodus*, Lapw.

Hor. and Loc.—Lower Llandeilo, Wales.

5. *Didymograptus arcuatus* (Hall).
   Graptolithus arcuatus, Hall.

Quebec Group, Canada.

6. *Didymograptus extenuatus* (Hall), Lapw.
   Graptolithus extenuatus, Hall.

Quebec Group, Canada.

7. *Didymograptus similis* (Hall), Lapw.
   Graptolithus similis, Hall.

Quebec Group, Canada.

8. *Didymograptus superstes*, Lapw.
Lower Bala, Ireland; doubtfully near Albany, N.Y.
9. *Didymograptus nitidus* (Hall), Nich., Ether., Lapw.
Graptolithus nitidus, Hall.
Quebec Group, Canada; Skiddaw Slates; Arenig, Australia; doubtfully in *Phyllograptus*-shales, Norway.
10. *Didymograptus suecicus*, Tullb., Lapw., Brögger.
Tetragraptus-zone, Skåne; *Phyllograptus*-shales, Norway ?

b. Type *Didymograptus Murchisoni*, Beck.

11. *Didymograptus Murchisoni* (Beck), Baily, Törnquist, Hopk., Nich., Trom. and Lebesc., Lapw., Tullb.
Graptolithus Murchisoni, Beck, Boeck.
Prionotus (?) *geminus*, His.
Graptolithus geminus, Scharenb., Kjerulf.
Didymograptus furcillatus, Hopk. and Lapw.
Angle of divergence about 40°.
Lower Llandeilo, Wales; *Didymograptus-Murchisoni* zone (Et. 4.) Norway, Skåne, France, Portugal.
12. *Didymograptus indentus* (Hall), Hopk. and Lapw., Brögger, Tullb.
Quebec Group, Canada; Upper Arenig, Wales; *Phyllograptus*-shales, Norway; zone with *Tetragraptus*, Skåne.
13. *Didymograptus indentus*, var. *nanus*, Lapw. and Hopk.
D. geminus, Nich.
Skiddaw slates, N. England; Upper Arenig, Wales; Lower and Middle Llandeilo, Wales.
14. *Didymograptus minutus*, Törnquist, Lapw.
Phyllograptus-shales, Dalecarlia.
15. *Didymograptus bifidus* (Hall), Nich., Hopk., and Lapw., Brögger, Tullb.
Angle of divergence 15°–20°.
Quebec Group, Canada; Skiddaw Slates, N. England; Upper Arenig, Wales. A somewhat divergent form in *Phyllograptus*-shales, Norway; zone with *Phyllograptus typus*, Skåne; Upper Arenig, N. England.

c. Type *Didymograptus fasciculatus*, Nich.

16. *Didymograptus fasciculatus*, Nich., Lapw.
Upper part of Skiddaw Slates.
17. *Didymograptus arcuatus* (Hall), Nich.
With a process opposite to the sicula. Quebec Group, Canada.

d. Type *Didymograptus pennatulus* (Hall).

18. *Didymograptus pennatulus* (Hall), Hopk. and Lapw.
Angle of divergence nearly 180° (Hall).
Quebec Group, Canada; Lower Arenig, Wales.
19. *Didymograptus sparsus*, Hopk., Lapw.
Lower Arenig, Wales.
20. *Didymograptus gibberulus*, Nich., Lapw.
Lower part of Skiddaw Slates, N. England.

e. Type *Didymograptus affinis*, Nich.

21. *Didymograptus affinis*, Nich., Hopk. and Lapw., Törnquist.
Angle of divergence 90°–150°.
Skiddaw Slates, N. England; Upper Arenig, Wales; doubtfully in *Phyllograptus*-shales, Dalecarlia.

22. *Didymograptus filiformis*, Tullb., Lapw., Brögg.
Tetragraptus-zone, Skåne; *Phyllograptus*-shales, Norway.

23. *Didymograptus Nicholsoni*, Lapw., Hopk. and Lapw.
D. serratulus, Nich.
Upper Arenig, Wales; upper part of Skiddaw Slates, N. England; doubtfully in *Phyllograptus*-shales, Norway.

24. *Didymograptus pusillus*, Tullb., Lapw., Brögger.
Angle of divergence 145°–165°.
Tetragraptus-zone, Skåne; ? *Phyllograptus*-shales, Norway.

25. *Didymograptus serratulus* (Hall), ? Lapw.
Hudson's River Group, New York; ? Utica Slates, New York.

26. *Didymograptus striatulus*, Linnarsson, Nich., Lapw.
Lower Graptolite shales, West Gothland.

f. Type *Didymograptus V-fractus*, Salter.

27. *Didymograptus V-fractus*, Salt., Nich., Lapw., Brögg., Tullb.
Skiddaw Slates, N. England; *Tetragraptus*-zone, Skåne; Lower part of *Phyllograptus*-shales, Norway.

28. *Didymograptus balticus*, Tullb., Lapw.
Resembles the preceding.—Angle of divergence 60°–105°.
Tetragraptus-zone, Skåne; *Phyllograptus*-shales, Norway.

29. *Didymograptus Pantoni*, M'Coy, Salt., Ether., Lapw.
Skiddaw Slates, N. England; Australia.

30. *Didymograptus vacillans*, Tullb., Lapw., Brögger.
Tetragraptus-zone, Skåne; *Phyllograptus*-shales, Norway.

31. *Didymograptus*, sp. (*Hisingeri*, Baily). Lower Bala, Ireland.
One of the latest species of *Didymograptus*.

Genus II. Janograptus, Tullberg (Geol. För. Förh. vol. v. p. 314).

From the usually indistinct sicula two branches issue in opposite directions, or the whole hydrosoma is formed only of one branch. The sicula is probably pressed into one branch. The angle of divergence is very various. Hydrothecæ as in *Didymograptus*.

The genus, which is somewhat problematical, is one of the latest of the Dichograptidæ. Its structure shows a remarkable agreement with that of an irregularly developed Monograptid (*M. lobiferus*, M'Coy), in which a second branch may sometimes be produced.

1. *Janograptus laxatus*, Tullberg.
Gymnograptus Linnarssoni-zone, Skåne. A *Janograptus* is also mentioned in other *Glossograptus*-zones.

Other forms may be regarded as proceeding from a *Didymograptus*. The two branches may divide dichotomously, producing a four-branched form (*Tetragraptus*); or branchlets may issue from the two

branches (*Trichograptus*, etc.). The following genera come under the latter category :—

Genus III. Trichograptus, Nicholson.

Hydrosoma bilaterally subsymmetrically developed. Two principal branches on the celluliferous side, with a series of branchlets which remain undivided. Hydrothecæ of the type of *Monograptus Nilssoni*, Barr.

1. *Trichograptus fragilis*, Nich., Lapw.

Upper part of Skiddaw Slates, N. England.

2. *Trichograptus retroflexus* (Brögger).

Bryograptus retroflexus, Brögg.

Upper part of *Dictyograptus*-shales, Norway.

Genus IV. Bryograptus, Lapworth.

Hydrosoma bilaterally subsymmetrical, consisting of two composite branches, diverging at a small angle from a distinct sicula. From the two principal branches composite branchlets issue at small but irregular intervals.

1. *Bryograptus Kjerulfi*, Lapw., Brögger.

Graptolithus tenuis, Kjerulf.

Dictyograptus-shales, Norway.

2. *Bryograptus Callavei*, Lapw. Upper Cambrian, Shropshire.

3. *Bryograptus ramosus*, Brögger.

Lower part of the *Ceratopyge*-shales, Norway. A very similar species in abundance in shales below the *Phyllograptus*-shales at Christiania.

Genus V. Pterograptus, Holm (Öfv. Kongl. Vet. Akad. Förh. 1881, p. 74).

The hydrosoma issues from the wide end of the sicula. On the two primary branches simple secondary branches arise from a number of the hydrothecæ towards the apex, and these are bent alternately to right and left of a plane passing through the primary branch, and turn their cell-bearing side towards this plane.

Fig. 6*b*. Fig. 6*a*. Fig. 5. Fig. 4.

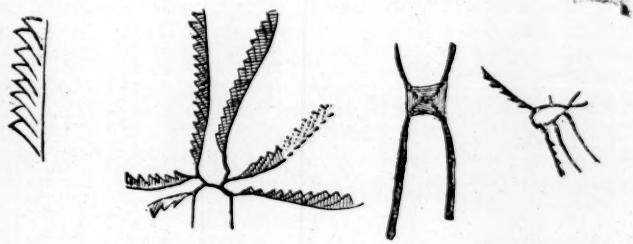

Fig. 4. *Pterograptus dilaceratus*, sp. nov.
Phyllograptus-shales, Galgenberg, Christiania.

,, 5. *Tetragraptus approximatus*, Nich.
Phyllograptus-shales, Fure, Ringerike, Norway.

,, 6*a*. *Dichograptus Sedgwickii*, Salter (formation and locality as in Fig. 4.)

,, 6*b*. Part of a branch of Fig. 6*a*, enlarged twice nat. size to show the form of the hydrotheca.

1. *Pterograptus elegans*, Holm, Tullberg.

Graptolithus Murchisonii, Boeck ; *G. gracilis*, Kjerulf.

Primary branches diverging in curves at an angle of 50°–60°.

Didymograptus Murchisoni-zone (Et. 4), Norway ; zone with *D. Murchisoni*[1] *geminus*, Skåne.

2. *Pterogaptus acutus* (Hopk.), Holm.

Ptilograptus acutus, Hopk.

Primary branches diverging at an angle of 30°–40°.

Lower Llandeilo, Wales.

3. *Pterograptus* (?) *dilaceratus*, sp.n. (Woodcut, p. 17, Fig. 4.)

Hydrothecæ as in *P. elegans*, Holm. Secondary branches narrow and thin, never so rigid as in that species. Angle of divergence of the two primary branches probably about 180°. The hydrosoma is always fragmentary (sicula not seen attached). Not unfrequently a primary branch is met with, from the hydrothecæ of which closely approximated branchlets project. It is sometimes rolled up circularly, often only gently curved, or bent and broken into a zigzagged form.

Genus VI. Pleurograptus, Nicholson.

Secondary branches proceed from both sides of the primary branches, and themselves again give off branches ; primary branches diverging at an angle of about 180°.

Referred by Lapworth to the Nemagraptidæ.[2]

1. *Pleurograptus vagans*, Nich.

Skiddaw Slates, N. England ; *Phyllograptus*-shales, Norway.

2. *Pleurograptus linearis* (Carr.), Nich., Lapw.

Cladograpsus linearis, Carruthers.

Upper Llandeilo, England ; Hartfell Shales, Scotland.

3. *Pleurograptus radiatus*, Lapw. Hartfell Shales, Scotland.

The four-branched forms resulting from the dichotomous division of a *Didymograptus* constitute

Genus VII. Tetragraptus, Salter.

Hydrosoma bilaterally symmetrically developed, consisting of four simple equivalent branches. A central disc may or may not be present.

The four-branched forms may be brought into two natural groups:

a. The two short branches issuing from the broad end of the sicula diverge at an angle of about 180°, *e.g. T. quadribrachiatus* (Hall). Thus is formed a funiculus uniting the two halves of the hydrosoma, but this may be reduced until it nearly disappears (*e.g. T. Hicksii*, Hopk., and *T. Halli*, Hopk.).

β. The two branches which originate from the sicula diverge at an angle of $\angle 180°$ (*T. fructicosus* (Hall)).

Group *a*.

1. *Tetragraptus quadribrachiatus* (Hall), Nich., Ether., Hopk. and Lapw., Linnars., Törnq., Brögg., Herrm., Tullb.

Graptolithus quadribrachiatus, Hall, M'Coy.

Tetragraptus crucialis, Salt.

[1] *Phyllograptus*-shales, Norway.

[2] See Notes on British Graptolithes, by C. Lapworth, F.G.S., Geol. Mag. 1873, Vol. X. p. 558, and Table I.

Quebec Group, Canada; Skiddaw Slates, N. England; Arenig, Australia; Middle Arenig, Wales; *Phyllograptus*-shales, Norway, Dalecarlia; *Tetragraptus*-zone, Skåne.

2. *Tetragraptus Halli*, Hopk. and Lapw.
Middle Arenig, Wales.

3. *Tetragraptus Hicksii*, Hopk. and Lapw.
Middle Arenig, Wales.

4. *Tetragraptus serra* (Brongn.), (Gein.), Hopk. and Lapw., Törnq.

Fucoides serra, Brongn.
Cladograptus serra, Gein.
Graptolithus bryonoides, Hall.
Tetragraptus bryonoides, Salt., Nich.
Didymograptus bryonides, Carr., M'Coy.

Arenig and equivalents in Wales, N. England, Canada, Norway, Skåne, Westgothland, and Dalecarlia; Newfoundland.

5. *Tetragraptus denticulatus* (Hall), Lapw.
Quebec Group, Canada; Silurian, Victoria ?

6. *Tetragraptus crucifer* (Hall), Nich., and Lapw.
With a central disc.
Quebec Group, Canada; Skiddaw Slates, N. England.

7. *Tetragraptus alatus* (Hall), Lapw.
With a central disc.
Quebec Group, Canada.

8. *Tetragraptus Headi* (Hall), Nich., Lapw.
With a central disc.
Quebec Group, Canada; Newfoundland; Lower part of Skiddaw Slates, N. England.

9. *Tetragraptus caduceus* (Salt.).

Didymograptus caduceus, Salt., Nich., M'Coy.
Phyllograptus similis, Hall.
Graptolithus Bigsbyi, Hall.
Tetragraptus Bigsbyi, Linnars., Lapw.

Skiddaw Slates, N. England; Quebec Group, Canada; *Phyllograptus*-shales, Norway, Skåne; Australia (Ether., Ann. Mag. N. H. ser. 4, vol. xiv. pl. iii. figs. 3, 4).

10. *Tetragraptus approximatus*, Nich., Lapw. (Woodcut, p. 17, Fig. 5.)
Quebec Group, Canada; *Phyllograptus*-shales, Norway. Norwegian specimens differ in not having the branches so close together as in Nicholson's figure; the curvature on both sides of the branches is sharper, and the branches do not so soon become parallel, and do not continue so exactly parallel as Nicholson indicates. One specimen from near Fure, in Ringerike, showed traces of a central disc.

Group β.

11. *Tetragraptus fructicosus* (Hall), Lapw., Brögg., Herrm., Tullb.

Graptolithus fructicosus, Hall.
Didymograptus fructicosus, Ether., M'Coy.

Quebec Group, Canada; Llandeilo Flags, Australia; *Phyllograptus*-shales, Norway; *Tetragraptus*-zone, Skåne; Arenig, Australia (according to Lapworth).

From *Tetragraptus* two different groups of forms may be derived. The four branches may divide dichotomously, producing hydrosomata with eight or more branches (*Dichograptus*, Salt.); or secondary branches may shoot forth from the four primary branches upon one or both sides. The latter is the case in the following five genera.

Genus VIII. Schizograptus, Nicholson.

Hydrosoma bilaterally subsymmetrical, composed of four primary branches, which issue in the form of a cross from the starting-point. Each of these branches developes a series of rigid branchlets which originate on each primary branch from the same side, and apparently do not again divide. Hydrothecæ as in *Monograptus sagittarius*, His. No central disc.

1. *Schizograptus reticulatus*, Nich., Lapw.
   Dichograptus reticulatus, Nich.

Lower part of Skiddaw Slates, N. England.

Genus IX. Trochograptus, Holm (Öfv. Kongl. Vet. Akad. Förh. 1881).

Constructed exactly like the preceding genus, except that the secondary branches give off branchlets always upon the same side.

1. *Trochograptus diffusus*, Holm, Brögger.
   Phyllograptus-shales (Et. 3, *b*), Norway.

Genus X. Ctenograptus, Nicholson.

This genus, provisionally established by Nicholson, probably belongs to this group. The fragment figured by Nicholson resembles a portion of *Trochograptus diffusus*, figured by Holm, except that the hydrothecæ appear to be essentially different.

1. *Ctenograptus annulatus*, Nich.
   Dichograpsus ? annulatus, Nich.

Lower part of Skiddaw Slates, N. England.

Genus XI. Provisional.

1. *Graptolithus Richardsoni*, Hall, from the Quebec Group. The mode of division of the branches as shown by the fragment figured resembles that of *Ctenograptus*. But the commencement of the hydrosoma is unknown, and we have no knowledge of the number of primary branches.

Genus XII. Holograptus, Holm (*loc. cit.*).

Hydrosoma bilaterally subsymmetrical. From the four primary branches branchlets are given off on both sides at irregular intervals. Hydrothecæ as in *Didymograptus*.

1. *Holograptus expansus*, Holm.
   Phyllograptus-shales, West Gothland.

Genus XIII. Goniograptus, M'Coy (Prodr. Pal. Vict. dec. v.)

1. *Goniograptus Thureaui*, M'Coy, Lapw.
   Arenig, Australia.

These smaller genera scarcely contain more than a single species each, and probably in their case the establishment of genera has been

carried too far. This opinion also seems to be held by Tullberg (Skåne's Graptoliter ii.). It would be better to regard them as subgenera of the two great genera *Didymograptus* and *Tetragraptus*.

All the many-branched Dichograptidæ may be conceived as originating from a *Tetragraptus* by repeated furcation. A division, repeated in all branches, produces eight-branched forms; further complete furcations give 16-branched forms and so on. Hitherto the 8-branched forms constituted the genus *Dichograptus*, Salt., and those with 16-32 branches the genus *Loganograptus*, Hall. But in considering the various forms with 8 and more branches, we are at once struck with an important contrast to those with 2 and 4 branches. The latter, when perfectly preserved, invariably possess only 2 and 4 branches; but in the many-branched forms a remarkable variation occurs in the number of branches; more and more frequently the full number is either not developed or exceeded, imperfectly or abnormally developed individuals become more and more numerous, so that the number of branches becomes of less and less value as a distinctive character. Thus in the multiramose species of the genus *Clonograptus*, Hall, the number of branches oscillates between 40 and 60 for the same species. The number of branches becomes finally so complicated as to be quite unimportant (*e.g. Clematograptus multifasciatus*, Hall). Thus the genus *Loganograptus*, Hall, with 16–32 branches appears to be quite arbitrary and artificial, and must be suppressed, unless we are prepared to establish a genus for every many-branched species. It has been proposed to refer all species with more than four branches to *Dichograptus*, Salt., which has hitherto included only 8-branched forms. But upon this the author would put a limitation, as there is in the many-branched forms a striking difference. "Thus either all the points of furcation are situated in the immediate vicinity of the sicula (*e.g. Dichograptus Kjerulfi*, Herrm., Fig. 8), while the more distant parts of the branches remain undivided; or there are greater distances between the individual points of furcation, so that the branches may divide throughout their whole length, and the points of furcation may depart far from the centre of the hydrosoma (*e.g.* Fig. 9)." For the latter forms Hall has proposed the name of *Clonograptus*, which may stand, and thus we get two homologous series forming the genera *Dichograptus*, Salt., and *Clonograptus*, Hall, each including forms with 8, 12, 16, and more branches.

Genus XIV. Dichograptus, Salt. (modified).

Hydrosoma bilaterally symmetrical. From the broad end of the sicula, which is directed upwards, issue two short oppositely diverging branches, which fork. Of the four branches thus produced, all or a part may again divide dichotomously once or several times *at very short distances*, so that more than four equivalent, simple branches are produced. The proximal parts of the hydrosoma are frequently enclosed in a central disc. Hydrothecæ as in *Didymograptus*, M'Coy.

1. *Dichograptus octobrachiatus* (Hall), Nich., (M'Coy), Lapw., Brögg. (Fig. 7.)

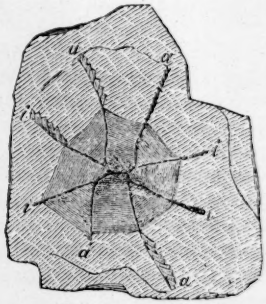

Fig. 7. *Dichograptus octobrachiatus*, Hall, from the Phyllograptus-shales, Galgenberg, Christiania (natural size).

Graptolithus octobrachiatus, Hall.
Graptolites (*Didymograptus*) *octobrachiatus*, M'Coy.
Loganograptus Kjerulfi, Herrm. *ex parte*.

The central disc may or may not be present. In the typical condition the species has eight branches, but specimens are frequent with more or fewer branches.

Quebec Group, Canada; lower part of Skiddaw Slates, N. England; *Phyllograptus*-shales, Norway; Arenig, Australia.

2. *Dichograptus octonarius* (Hall), Lapw.

Graptolithus octonarius, Hall.

Central disc unknown. Quebec Group, Canada.

3. *Dichograptus Sedgwickii*, Salt. (Figs. 6*a*, 6*b*.)

Figured but not described by Salter (Q.J.G.S. vol. xix. p. 138).

The author describes the species:—

In the typical condition the hydrosoma consists of eight simple, curved branches, which are arranged as in *D. octobrachiatus*, Hall. There is in this species the same variation in the number of branches as in *D. octobrachiatus*, which is its nearest ally, the differences between them consisting in the curvature of the branches, and the habit of the hydrothecæ. Of the latter there are eight in a length of ten millim. Their lower border is curved and forms with the axis an angle of 10°—12° at the proximal end, of about 30° at the distal end. The apertural angle is about 90°, and the hydrothecæ, which are about one-half longer than broad, are half free, appearing as pointed, nearly perpendicular teeth (Fig. 6*b*). No central disc has been observed either in English or Norwegian specimens.

Skiddaw Slate (lower part), N. England; lower part of *Phyllograptus*-shales, Norway.

4. *Dichograptus Kjerulfi* (Herrm.) (Woodcut, p. 23, Fig. 8).

Loganograptus Kjerulfi, Herrm. *ex parte*.

In 1882 (Nyt Mag. for Naturv. xxvii. pp. 341-362) the author described and figured, under the name of *Loganograptus Kjerulfi*, a number of forms which subsequent study showed him must be

separated. The eight-branched forms, with some abnormally developed examples, are referred to *D. octobrachiatus*, Hall. The forms furnished in the typical state with twelve branches are to be regarded as a distinct species, and that these examples cannot be referred either to *D. octobrachiatus* (Fig. 7) or to *D. Logani*, Hall, seems to the author to follow from the facts that in some localities only eight- and many-branched forms (*D. Logani*, Hall) have been found (*e.g.* Australia and Canada), in others only those with numerous branches (*e.g.* the Australian localities examined by R. Etheridge, jun.), and in other localities again only eight-branched forms. In the locality investigated by the author (Galgenberg, Christiania) the forms with 8 and 12 branches occur together, and he considers that here two different species are associated. Further, the twelve-branched forms constitute a bilaterally symmetrical species, and the number of normally developed examples as compared with abnormal ones seems to indicate their distinctness.

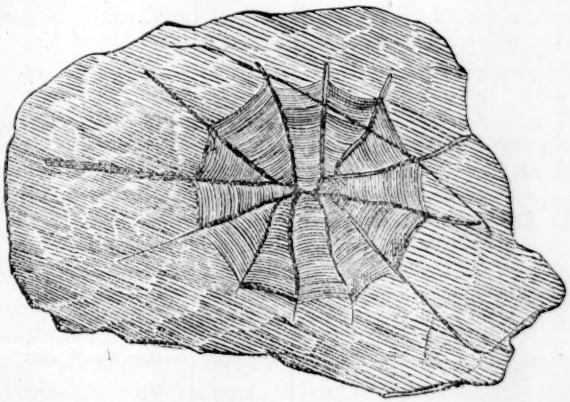

Fig. 8. *Dichograptus Kjerulfi*, Herrmann, Phyllograptus-shales, Galgenberg, Christiania (natural size).

Description.—Hydrosoma bilaterally symmetrical, consisting of 12 branches when typically developed. From a sicula, which usually persists as a rounded knob, issue 2 short branches, which bifurcate first into 4 and then into 8 branches. Of these 8 branches, 4 again divide, and these four are almost always those situated furthest from the plane of symmetry, *i.e.* the inner branches of each half of the hydrosoma of an octobrachiate form (Fig. 7*i*). The branches are slender, thinnest in the neighbourhood of the sicula. The full number of branches is frequently not attained, and rarely exceeded. The central part of the hydrosoma is almost always enclosed in a chitinous disc. The hydrothecæ are rarely to be seen within the disc. There are 9 of them in a length of 10 millim. At the proximal end they form with the axis an angle of 13°—15°, at the distal end one of about 35°. They are three times as long as broad, and about one-third free. The lower border is curved. Aperture-angle 55°.

It has been thought that the forms described by the author (*loc. cit.*), constituting a continuous series of examples with from 5 to 14 branches, were to be regarded as individuals of different ages, the highest number of branches indicating the greatest age. The author regards this view as untenable. No difference is to be detected in the thickness and length of all the branches, such as would occur if any of them were formed subsequently to the rest, whereas it might be expected that the supposed younger branches would be observable when they had just sprouted, and before they reached the margin of the disc. It is also difficult to imagine how any such subsequent increase could be brought about, as the branches originate by bifurcation, which usually occurs only at the top of a branch. But the notion is disposed of by the fact that young individuals occur with 8, 9, and 12 branches, just as in full-grown examples.

Dichograptus Kjerulfi is found in the lower part of the *Phyllograptus*-shale (Kjerulf's Lower Graptolite-shales, Brögger's Etage 3*b*), and occurs in great abundance in a thin bed in the Galgenberg, near Christiania, associated with *D. octobrachiatus* (Hall), *Didymograptus constrictus* (Hall), etc.

5. *Dichograptus Logani* (Hall), Nich.

Graptolithus (*Loganograptus*) *Logani*, Hall.
Graptolites (*Didymograptus*) *Logani*, M'Coy.
Loganograptus Logani, Lapw.

Quebec Group, Canada; Skiddaw Slates (lower part), N. England; Australia. *D. Logani*, Etheridge, Ann. Mag. N. H. ser. 4, vol. xiv. pl. iii. fig. 12, is doubtful.

5 *b*. *Dichograptus Logani* (Hall.), var. *australis* (M'Coy).

Grapt. (*Didymogr.*) *Logani*, var. *australis*, M'Coy.

Arenig, Australia.

From *Dichograptus* new forms may proceed by the development of branchlets upon the primary branches. These form—

Genus XV. Clematograptus, Hopkinson.

Hydrosoma much ramified, bilaterally subsymmetrical. From a short funiculus issue a great number of primary branches, from which numerous branchlets spring on one or both sides, at irregular distances, often closely packed together. Hydrothecæ as in *Dichograptus*. No central disc.

1. *Clematograptus implicatus*, Hopk., Lapw.

Loganograptus? implicatus, Hopk.

Middle Arenig, Wales.

2. *Clematograptus multifasciatus* (Hall), Hopk. and Lapw.

Graptolithus multifasciatus, Hall.

Hudson River Group, New York.

D. (*L.*) *Logani*, Etheridge (Ann. Mag. N. H. ser. 4, vol. xiv. pl. iii. fig. 11), from Australia, probably belongs to this genus.

Genus XVI. Clonograptus, Hall.

Hydrosoma bilaterally subsymmetrical, consisting of more than four simple branches produced by dichotomous division. The spaces

between the furcation-points are larger than in *Dichograptus*. Central disc never present.

There is some uncertainty about the species of this genus. Hall discovered in a loose block in America a form with 16 branches, which certainly belongs to this genus (*Cl. Milesi*, Hall); this is figured, but not described, by Hall. Nicholson found in the Skiddaw Slates two specimens of a form which must also be referred to this position. They possess a great number of branches (*C. multiplex*, Nich.). In the Norwegian *Phyllograptus*-shale the author has found a considerable number of specimens agreeing in character with the above, and especially with Nicholson's species, six of which have 8, and four 16 branches, while many others vary between 8 and 16 branches

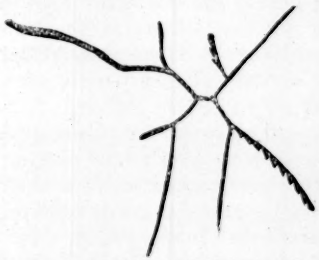

Fig. 9.

Fig. 9. *Clonograptus multiplex*, Nicholson, Skiddaw slates, Peel-Wyke, Bassenthwaite, Cumberland.

(Fig. 9). These were formerly identified by the author with *C. Milesi* (Hall), but he now regards this identification as doubtful. Nicholson's genus *Temnograptus* is not sufficiently distinct from *Clonograptus*.

1. *Clonograptus Milesi*, Hall.
   Graptolithus Milesi, Hall.
   Temnograptus Milesi, Nich.
2. *Clonograptus multiplex* (Nich.). (Fig. 9.)
   Dichograptus multiplex, Nich.
   Temnograptus multiplex, Nich., Lapw.

Skiddaw Slates, N. England.

3. *Clonograptus flexilis* (Hall), Nich., Lapw.
   Graptolithus flexilis, Hall.

Quebec Group, Canada.

4. *Clonograptus rigidus* (Hall), Nich., Lapw.
   Graptolithus rigidus, Hall.
   Graptolithus abnormis, Hall.

Quebec Group, Canada; *Phyllograptus*-shale, Norway.

5. *Clonograptus ramulus* (Hall), Lapw.
   Graptolithus ramulus, Hall, Törnq.

Quebec Group, Canada; *Phyllograptus*-shale, Dalecarlia.

Graptolithus Richardsoni, Hall, does not belong to this genus.

6. *Clonograptus tenellus* (Linnars.)
   Dichograptus ? tenellus, Linnars., Lapw.
   Trichograptus tenellus, Nich.

Olenus-shale, West Gothland.

The most ancient of known Graptolites, described by Linnarsson in 1871, as *Dichograptus ? tenellus*. Tullberg regards it as a *Bryograptus;* Nicholson refers it to his genus *Trichograptus*. The discoverer of the species noticed that its ramification agreed with that of *Clonograptus flexilis*; and until more perfect specimens are obtained, it may take its place here.

VI.—An inquiry into the Rate of Erosion of the Sea-coasts of England and Wales, and the Influence of the Artificial Abstraction of Shingle or other Material in that Action.

By C. E. De Rance, F.G.S., and W. Topley, F.G.S., Secretaries.[1]

The Committee has during the past year received several Returns relating to the south and east coasts of England. Most of those relating to the coast south of the Thames are printed.

The thanks of the Committee are especially due to Major-General Sir A. Clarke, who has instructed the Officers of the Royal Engineers stationed around the coast to supply the Committee with such information as they may possess or be able to obtain. Further returns are expected from the same department and from other official sources; the Committee therefore think it best to defer any general report until more complete information is obtained.

The Memorandum drawn up by Mr. J. B. Redman so fully sets forth the work of the Committee, and the importance of the inquiry referred to it, that this is now printed.

The Memorandum by Mr. G. Dowker on East Kent gives a sufficiently complete account of the changes of the coast in this district; changes which are of especial historical importance and interest.

Mr. Whitaker has drawn up a list of works relating to the coast-changes of England and Wales, which will be of great service to the Committee and to those who may assist in the work.

The Committee would again ask for the assistance of any who by long residence or other means have special knowledge of changes on any part of the English and Welsh coast. Printed forms of questions can be obtained from any member of the Committee.

Extracts from the Memorandum by Mr. J. B. Redman, M.Inst.C.E.

That the erosion of our south-eastern coasts by the action of wind and waves has been assisted and increased by artificial agency, by removal of material and by the treatment of works of defence in a selfish spirit, unaccompanied by concerted action, resulting in injury to adjoining frontages for the benefit of those operated on, can be copiously illustrated by the records of our public departments, such as the Admiralty, Woods and Forests or Works, the Board of Trade, the War Office, and the Trinity Corporation, as well as by those of nearly every harbour board, river conservancy, or local drainage and sewage authority. And this fact is portrayed in a special literature

[1] Being the substance of a Report laid before the British Association at Aberdeen, and read in Section C. Geology, 1885.

of its own, the Blue Books of the House of Commons, for the various tidal harbours' reports, inaugurated by the persistent agitation of the late Joseph Hume, M.P., as well as those on harbours of refuge, lighthouses, and shipping, give incidentally numerous isolated cases showing how much this really imperial question has been overlooked or confused by a division of authority, and the struggles with lords of the manor, illustrated by a number of well-known cases, adds additional exemplification.

The legal aspect of this question has been recently ably treated on by a republication of "Hall's Essay on the Rights of the Crown in the Sea-shore," by Richard Loveland Loveland, of the Inner Temple, in 1875, and this work shows well the imperial character of the inquiry deputed to the British Association Committee on the Erosion of the Sea Coasts of England and Wales.

As regards the wholesale removal of shingle and boulders from marine spits and moles, it is only necessary to refer to such cases as the quarrying of cement stones from the foreshores on either side of Harwich, from the Beacon cliff to the southward, and from the Felixstow cliffs to the northward, only stopped by the persistent efforts made by Captain Hewett's successor in the North Sea Survey, the late Admiral Washington, and others. For illustration of this pernicious practice and the deplorable results frequently entailed this case suffices. Again, on the northern side, the indiscriminate removal of shingle from the northern breakwater of Harwich harbour (Landguard Point) for ballastage by the lord of the manor has been the fruitful source of litigation. Similar results from similar practices at Spurn Point, at the mouth of the Humber, have been entailed. In effect, this natural shingle mole, defending the entrance to the most important harbour on our eastern coast, was nearly breached in consequence.

Next to the removal for ballastage, the most fertile cause is removal of material for road-making and for building purposes, and when in the neighbourhood of a large town this becomes, from the enormous quantity removed in the aggregate, sufficient to tell eventually on the oscillating natural foreshore protection. Take the case of Hastings: for the last half-century there has been a constant draw on the material for such purposes. The quantity used must be enormous, and in effect the new portion of the town may almost, without figure of speech, be described as in a large measure built out of the sea. About 1836 Hastings was separated from St. Leonards by a small marshy bottom, with a rill of water running through it, called the "Priory Marsh," and during that year the sea was excluded by the erection of a vertical stone wall joining the esplanade terraces, and the two towns became what it is now, one big town. Since that wall was erected the shingle in front of it has, from various causes, become much attenuated, the groynes destroyed, and the sea has, it is said, in places got under the sea walls. So great has been the loss in the bay to the eastward, where is situate the old portion of the town, the fishermen's quarter, that a general exodus of that industry to Rye, or elsewhere, has been threatened.

A second groyne is being constructed from the base of the cliff below the castle (where a similar work formerly existed) at a very great cost, in order to promote accumulation of shingle along the Hastings frontage, and to bring about again the old state of things.

The argument made use of by many owners of property here, as elsewhere, to the effect that removal of shingle for building purposes must be inappreciable (as however great the abstraction for such purposes, millions of tons renew the shore after a change of wind) is made in evident forgetfulness or ignorance of the fact that these abstractions from and renewals to the natural "fulls" of beach, alternately reduce and increase what is a circulating medium of defence, moving in opposite directions up and down channel, with a preponderating movement up-channel due to prevalence of south-west winds, and that such a constant drain on a natural defence, however recuperative, must tell in the long run.

The removal of boulders from the foreshore seaward of the summit shingle neap and spring "fulls," either for road-making or for manufacturing purposes, not only loosens the foreshore, and renders it, thus disintegrated, less able to resist the stroke of the wave, but in many cases, such as the "Chenies" rock off Sheerness, and the "Septaria" blocks off Harwich, the material formed natural groynes and breakwaters, and their removal, in reference to shore conservancy, was most suicidal.

Another fertile source of accelerated erosion of a special locality is the erection of a close pier for a harbour entrance, and of large and lofty groynes for accumulating shingle, looking only to the protection of an isolated frontage, and without reference to the attendant abstraction of material to the leeward of such works, from the absolute stoppage of the material on its way to the less favoured locality. The case is parallel to the last, as the oscillating medium is laid under heavier contribution for a favoured locality, and is gradually starved for the neglected neighbour to leeward.

Folkestone may be cited as a principal delinquent of this class, due to the elongation of the close pier to the windward or westward of its harbour, which half a century back was a trap for shingle, and a fisherman's first task in the early morning, prior to that, was to excavate a channel through the newly-arrived shingle to get his boat through and out to sea. The resultant accumulation of shingle to windward forms the tongue of land on which stands the "Pavilion," etc.

Now, in "East Wear" Bay there is an almost entire absence of shingle, and the resultant falls of the chalk undercliff take place at so alarming a rate that the very existence of the South-Eastern Railway is jeopardized. That this action is not due to the Admiralty Pier at Dover is shown by the entire absence of shingle to windward of that work, but in its place a remarkable extension of the silty foreshore has taken place, gradually diminishing towards Folkestone. Eastward of Dover we have similar results from the same cause; from the Castle Jetty to St. Margaret's the base of the lofty chalk cliff is now washed and abraded by the waves, and the lower *débris*

and shingle, forming an undercliff carriage-way into Dover some thirty years back, has now entirely disappeared.

We may be asked to suggest a remedy, but this, perhaps, is beyond the province of this Memorandum; but as regards the old stereotyped plan of building a solid pier out from the shore, for communication therewith from vessels, or for protection of the outfall of a tidal river, it has been suggested that there are numerous cases, where a moving beach has to be crossed, that it would be better to commence the solid work altogether seaward of the shingle "fulls," and connect it with open piling to the shore, and so as to leave the littoral movement of beach uninterfered with.

As respects groynes, there is hardly a watering-place on our southern coast where they have not become a burning *vexata quæstio* of the day, and at most of them illustrate the suggestion made more than thirty years back, that groynes cut up a shore into a multitude of bays, with a repletion of material on one side and deep water on the other, and would have had a better substitute in a sea-wall that allowed the shingle to pass freely backwards and forwards along its face. Such was the experience with the frontage of Romney Marsh, defended by Dymchurch sea-wall, $3\frac{1}{4}$ miles in length, where the old system of groynes, which cut up the frontage into an interminable number of bays, was abandoned about forty years back in favour of the present stone slope.

The system of groynes at Brighton, for some isolated points, appeared to have answered well when the supply arriving at that town of shingle from the westward was uninterfered with, but a change occurs when the system was continued to Hove, or West Brighton, in thickening quantities. The material arriving was a constantly diminishing one, from the fact that the Shoreham Gas Works, erected under an Act of Parliament on the "live" beach between the harbour and the sea, were found to stand upon a somewhat unstable base, with a fickle sea defence, unless supplemented by artificial works. Groynes on an extended scale were erected, which treated West Brighton in the same ungenerous spirit entertained in former days for Rottingdean, for the sake of and advantage of Kemp Town. The encroachment of the sea to the leeward side of the groynes, on the esplanade lawns, has necessitated the erection of an esplanade wall.

NOTICES OF MEMOIRS.

Brief Notices of Papers Read before Section C. Geology, British Association Meeting, Aberdeen, 1885.

I.—The Chasm called the Black Rock of Kiltearn.

By William Watson.

THIS is a narrow ravine in conglomerate: its length is about $1\frac{1}{4}$ mile; its depth varies from 100 to 130 feet; its breadth at the top varies from 12 to 15 to about 30 feet. The river which flows through the ravine is the Altl-Gránda; it drains Glen Glass (above the ravine); the water flows into Cromarty Firth.

The author refers to popular views held to explain the formation of the ravine—earthquakes and fracture—and shows that these are inadequate. The ravine has clearly been produced by erosion, of which the marks are still visible on the sides; the difficulty is to explain how erosion could have produced a gorge of this kind without weathering action and floods having denuded the sides.

Above the gorge in Glen Glass was once a lake. This had been silted up to the height of about 80 feet with sand, washed out of the Glacial *débris* of the glen. When the barrier that confined the lake gave way, the river flowed over the surface of the conglomerate, carrying with it much sand from the lake silt, and using this as a means of rapidly eroding the rock. When the chasm was deep enough to prevent the floods from overflowing the banks, the sides could not be widened to any great extent. The disproportion between the deepening and widening process has been maintained, thus causing the steep-sided narrow glen. The excavation now going on is small, whilst the weather has some effect on the sides; so that ultimately there will be produced an ordinary valley.

II.—Notice of an Outline Geological Map of Lower Egypt, Arabia Petræa, and Palestine.

By Prof. Edward Hull, LL.D., F.R.S., F.G.S.

THE map exhibited was enlarged from that which accompanies the author's book "Mount Seir, Sinai, and Western Palestine," giving a narrative of the expedition sent out into these countries by the Palestine Exploration Society in 1883-84. It embraces a region extending from the valley of the Nile on the west to the table-land of Edom (Mount Seir) and Moab, including the Jordan, Arabah Valley, and the mountains of Sinai. Its northern limit is the Lebanon. The following formations and divisions are represented:—

Recent.	1. Sandhills of Lower Egypt, the coast of Palestine, and Arabah Valley. 2. Alluvial Deposits of the Nile, the Ghor, and Jordan Valley. 3. Gravel of the Wâdy el Arabah.
Recent and Post-Pliocene to Pliocene.	1. Raised Beaches bordering the Gulfs of Suez and Akabah, the Isthmus of Suez, and borders of Palestine. 2. Ancient Deposits of the Salt Sea (Dead Sea). 3. Old Lake-beds of the Sinaitic Peninsula and Arabah Valley.
Eocene to Cretaceous.	1. *Upper Eocene.* Calcareous Sandstone of Philistia. 2. *Middle and Lower Eocene.* Nummulite Limestone. 3. *Upper Cretaceous.* Cretaceous Limestone. 4. *Cenomanian.* Nubian Sandstone.
Lower Carboniferous.	1. Limestone of Wâdy Nasb. 2. Desert Sandstone and Conglomerate.
Metamorphic Rocks (Archæan ?).	Granite, Gneiss, and various kinds of Schist.
Modern Volcanic Rocks.	Basalt, Dolerite, etc.
Ancient Volcanic or Plutonic Rocks.	Granite, Porphyry, Felstone, Diorite, etc. Beds of Tuff and Agglomerate of Wâdy Haroun and Jebel esh Shomrah.

The main lines of fault and dip of the strata are also indicated.

As an outline of the scientific results which were arrived at by the members of the expedition, and which are represented on the map, had already been communicated to the Association,[1] it was not considered necessary to repeat them here, but the author wished to add that a topographical and geological map of the Arabah Valley on a scale of about six miles to one inch was in preparation, and would accompany the Geological Report now in the press for the Palestine Exploration Society. The topographical survey had been made by Major Kitchener, R.E., and Mr. John Armstrong (formerly sergeant-major, R.E.), and the geological details had been inserted by the author. In addition to these, several longitudinal geological sections illustrating the structure of various parts of this region, and numerous drawings would accompany the memoir.

III.—On the Occurrence of Lower Old Red Conglomerate in the Promontory of the Fanad, North Donegal.

By Professor Edward Hull, LL.D., F.R.S., F.G.S.,
Director of the Geological Survey of Ireland.

THE district in which the Old Red Conglomerate occurs is formed of ridges and valleys of metamorphic rocks, consisting of beds of quartzite, schist, crystalline limestone, and trap, chiefly diorite. It lies between Lough Swilly and Mulroy Bay, and is washed on the north by the waters of the Atlantic. The remarkable tract of the Old Red Conglomerate, recently discovered by the officers of the Geological Survey, is far remote from any mass of the same formation, and it is unrepresented on any geological map hitherto published.

The beds consist of red and purple sandstones and conglomerates, made up chiefly of quartzite pebbles and blocks, but also containing others of limestone and trap; all derived from the surrounding metamorphic series. They occupy an area of over two miles in length and half a mile across, extending along the northern base of Knock Alla, a ridge of quartzite which traverses the promontory from side to side. The beds dip against the base of the mountain, against which they are let down by a large fault, and they terminate along their northern edge by an unconformable superposition on beds of quartzite and limestone. They reach a total thickness of about 800 feet.

From the position of these beds it becomes evident that they are unconnected with any of the recognized basins of Lower Old Red Sandstone, either in Scotland or Ireland, and may, therefore, be regarded as having been formed in an isolated basin, which, following the example of Dr. Geikie, I may be allowed to name "Lake Fanad." The tract will be a new feature on geological maps of Ireland.

IV.—On Rocks of Central Caithness.

By John Gunn.

THE term "Central Caithness" is intended to embrace most of the parish of Halkirk and part of the parish of Watten. The

[1] Rep. Brit. Assoc. (Montreal Meeting, 1884), Transactions of Sections C and E.

upper part of the parish of Halkirk is covered by drift-gravel, underlying peat. At Loch More flagstones are presented. Below the lake may be traced the banks of what was once a great river. At Dirlot the rocks are sandstone, granite, gneiss, gneissic conglomerate, and limestone. At Dalmore the right bank of the Thurso is composed of Boulder-clay, the left of gravel. Here is seen a chain of moraines, composed of granitic gravel and sand. At Tormsdale a vein of some cinder-like material occurs. The flagstones at Poll a' Chreagan are covered with freestone, as also at Dale Bridge on the right bank of the river. On the left the flags lie exposed in great tabular masses, overlying limestone. At the top of the Mill Pool are the remains of a natural dam. Below this pool a band of freestone once crossed the bed of the river. At Dale are shifting beds of gravel, and here the river is continually changing it course. Below Polihour flags again appear, and opposite Scots Calder are banks of Boulder-clay, the boulders therein being very distinctly striated. Great masses of flagstone block up the bed of the stream at Gerston. At Halkirk the cliffs are coated with red ochre.

Granite is not visible at Dorrery, as has been stated by at least one writer, but it does not appear to lie at any great depth below the flags.

At Achanarras a curious fossil fish, *Coccosteus*, is found in a small slate quarry.

East from Spittal the angle at which the rocks dip gradually diminishes, and at Lanergill reaches its nearest approach to a dead level.

Drift gravel prevails in the neighbourhood of Halsary, and also down part of Strathberg, where the banks of the ancient river may again be traced. Here the Dalmore moraines are continued.

No evidence of volcanic action can be gathered from an examination of the rocks of Central Caithness, but the district presents a fair field for the study of erosion by ice, air, and water.

V.—On the Waterworks at Goldstone Road, Brighton.

By W. Whitaker, B.A., F.G.S., Assoc Inst.C.E.

NOTES of a visit underground in December 1884, when the water was pumped down for extending the galleries. These works are perhaps the best example of the right way of getting a very large supply of water from the Chalk, galleries being driven (in one case to the length of 800 feet) at about low-water level, so as to cut the fissures and intercept the water on its way to the sea.

The whole of the works (shafts and galleries) are in the White Chalk, with but few flints in the bedding-planes, but with many oblique layers along joint-planes. The supply comes chiefly from a few powerful springs, and, though small contributions issue between these, it is noteworthy how far a tunnel has sometimes been driven before reaching a fissure of large yield. Under these circumstances borings, or even shafts, might have failed to yield a large supply.

The roof of the north-eastern gallery is throughout of one bed, rarely needing support, a thin brittle layer of flint at its base being cleared away.

VI.—On some Rock Specimens from the Islands of the Fernando Noronha Group.

By Professor A. Renard, LL.D.

THE rock specimens described in this communication were collected by J. G. Buchanan, Esq., during the voyage of the "Challenger." The islands have been described by Darwin in his "Geological Observations on Volcanic Islands" (2nd edition, p. 27). The author, after having explained the geological structure, gives lithological descriptions of the chief types of the rocks, which may be referred to the phonolites (St. Michael's Mount). These phonolites are composed of sanidine, augite, nepheline, hornblende, magnetite, nosean, and titanite.

The rocks of Rat Island are basalts with nepheline. The constituent minerals are augite and olivine. The ground-mass is almost entirely composed of nepheline; biotite and apatite occur as accessory constituents. The little island known as Platform Island is also basaltic, with a doleritic texture. It is composed of labradorite, augite, olivine, magnetite, and biotite. The rock has undergone alterations.

VII.—Traces of Early Human Habitations on Deeside & Vicinity.

By the Rev. J. G. Michie, A.M.

CIRCULAR CAIRNS:—Their structure. Their probable uses—human dwellings; sepulchral purposes. Urns, chests (cists) found in connection (Migvie).

Yerd Houses:—General structure—examples in Cromer, Glenkindy, and Kildrummy. Probable uses. Generally found in the vicinity of round cairns and circular foundations.

Lake Dwellings (Crannogs):—Island in Lock Kinnord, Loch of Leys. Similar to those found in Wigtonshire and Ayrshire. Dr. Stuart's "Scottish Crannogs," and Dr. Munroe's "Ancient Scottish Lake Dwellings." Relics found in connection—canoes, arrow-heads, celts, stone knives, and stone cups.

Moated Forts:—Lumphanan, Invernochty, Rothiemurchus, and ruder form at Loch Davan.

Ancient Pictish Towns:—Character and situation. Davan—Short description of; probably the *Devana* of the Romans.

REVIEWS.

I.—Förteckning på Gotlands Siluriska Crustacéer. Af G. Lindström. Tafl. xii.–xvi. (Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlingar, 1885, No. 6. Stockholm.)

A Catalogue of the Silurian Crustacea of Gotland. By G. Lindström. 8vo. pp. 63, 5 Plates.

IN the thirty years which have elapsed since the issue of Angelin's great work "Palæontologica Scandinavica," there has been a great accumulation of fresh fossil material from Swedish strata, partly through the labours of Angelin himself, and partly through

the work of succeeding palæontologists; and Prof. Lindström has undertaken the desirable task of investigating its character. This memoir contains the results of his studies of the Silurian Crustacea of Gotland, from which locality 70 species of Trilobites, and two of Merostomata, are enumerated and described. New species belonging to the following genera are introduced, viz. *Phacops* (1); *Cheirurus* (1); *Sphærexochus* (2); *Lichas* (6); *Harpes* (1); *Calymene* (5); *Phaëtonides* (2); *Cyphasphis* (1); *Proetus* (6); *Illænus* (2); and *Bronteus* (3). A new genus, *Youngia*, based on the characters of *Cheirurus trispinosus*, Young, is formed, and includes two new species. Most of the forms are fragmentary, but the portions preserved retain their surface characters so perfectly, and these have been so clearly and exactly described and figured in the plates and woodcuts, that there should be no difficulty in identifying them. Prof. Lindström gives a table showing the distribution of the species in the four divisions of the Gotland strata, which correspond respectively to our Upper Llandovery, Wenlock Shale, Wenlock Limestone, and Ludlow beds; and from this it appears that in Gotland the Wenlock Limestone is the richest in species; that there are three species peculiar to the Upper Llandovery, ten to the Wenlock Shale, eleven to the Wenlock Limestone, and four to the Ludlow beds. Some species, as *Sphærexochus scabridus*, *Encrinurus punctatus*, and *Illænus barriensis*, appear in all the divisions, whilst all the species of *Lichas* are limited to the two upper divisions. Prof. Lindström further states the noteworthy fact that not one of these species is found in the strata below the marly shales, which are the equivalents of the Upper Llandovery, in Sweden. *Calymene Blumenbachii* has been reported to occur in underlying beds, but according to Lindström, the head-shields attributed to this species, found in West Gotland and in Dalecarlia, are too badly preserved to admit of satisfactory recognition. G. J. H.

II.—Atlas von China. Orographische und Geologische Karten; von Ferdinand Freiherr von Richthofen, zu des Verfassers Werk: China, ergebnisse eigener Reisen und darauf gegründeter Studien. Erste Abtheilung: Das Nördliche China. Berlin, Dietrich Reimer, 1885.

Atlas of China. Orographic and Geological Maps, by Ferdinand Freiherr von Richthofen, for the Author's work on China. First part, Northern China.

THE construction of a series of geological maps of such a vast and comparatively unknown country as China, must be a difficult and arduous task, even in the hands of such a competent geologist as Prof. von Richthofen. And yet in this Atlas we have, in addition to the orographical maps, thirteen large maps, each representing an area of 78,000 square kilomètres, on which the boundaries of the principal geological divisions of Northern China are delineated with great apparent precision! The basis of the work rests on the author's observations during his travels in the country, but these of course were limited to the comparatively narrow strip of territory

bounding his route; he has further combined the information obtained from other travellers and from the natives; but even so the mapping of the geological features of no small proportion of the country must have depended upon bold generalizations. Whatever may be the result of subsequent actual investigation by future Chinese or European geologists, this preliminary attempt to lay down the geological boundaries of this vast area cannot fail to be of great advantage and assistance to later workers, and deserves the warmest recognition. The maps are on the scale of 1 : 750,000; the colouring employed for the different geological divisions is partly similar to that adopted by the Geological Congress. This first part of the Atlas is intended to accompany the second volume of the author's great work on China, which has been already noticed in the GEOLOGICAL MAGAZINE.[1] G. J. H.

III.—LETHÆA ERRATICA, ODER AUFZÄHLUNG UND BESCHREIBUNG DER IN DER NORDDEUTSCHEN EBENE VORKOMMENDEN DILUVIAL GESCHIEBE NORDISCHER SEDIMENTÄR-GESTEINE. Von FERDINAND RŒMER. Mit 11 Tafeln und 3 Holzschnitten. Palæontologische Abhandlungen herausgegeben von W. DAMES und E. KAYSER. Zweiter Band. Heft 5. (Berlin: G. Reimer, 1885.)

LETHÆA ERRATICA, OR AN ENUMERATION AND DESCRIPTION OF THE DILUVIAL ERRATICS OF NORTHERN SEDIMENTARY ROCKS OCCURRING IN THE PLAINS OF NORTH GERMANY. By FERDINAND RŒMER. 4to. pp. 173. With 11 lithographed plates and 3 woodcuts.

IN the Boulder-clay which is so extensively distributed over the plains of North Germany and Russian Poland, besides the fragments of gneiss, granite, and other crystalline rocks, there are numerous broken-up portions of sedimentary strata, many of which abound in fossils. These fossiliferous erratics have long been studied by German palæontologists, more particularly by the veteran author of this work, and the present memoir, with its 11 lithographed plates of the principal fossils occurring in the Boulder-clay, is intended as a more complete description of them than that published by him in 1862.[2]

The author first gives a list of the principal memoirs which have appeared on the subject since 1828, and then refers briefly to the geological position of the Boulder-clay; the state of preservation of the boulders and fossils; the geographical extension of the deposit; the different formations to which the erratics belong; the original localities from whence they come; and the manner in which they have been transported to their present positions. Following this, is a detailed description of the different species of fossils, of the present distribution of each in the Boulder-clay, and of the beds in which the fossils now occur in other European areas.

The fossiliferous erratics belong to the Cambrian, Silurian, Devonian, Jurassic, Cretaceous, and Tertiary formations. The most

[1] Decade II. Vol. IX. p. 429.

[2] Zeitschrift der deutschen geologischen Gesellschaft, bd. 14, pp. 575.

abundant and widely distributed are boulders of limestone of Silurian age, belonging to what is known as the Orthoceren-Kalk, the Korallen-Kalk, and the Beyrichien-Kalk. The Silurian and Cambrian erratics have been brought partly from Sweden and partly from the Russian Baltic provinces. Boulders of Devonian age are rare, and limited to the eastern provinces of Prussia; they have undoubtedly been derived from Livonia and Courland. Only a few scattered fragments of Carboniferous and Permian rocks have been met with, and their original localities are unknown; whilst Triassic boulders appear to be entirely absent. Jurassic boulders are only met with in the Eastern half of the Boulder-clay area, as far as the Elbe. Their source is unknown, but they are most nearly related to Jurassic strata in Courland. Cretaceous boulders extend over the entire area; they belong both to the Cenomanian, Turonian, and Senonian divisions; the most abundant are flints, probably derived from the Chalk of Denmark and the South of Sweden. No erratics are known from the Gault and the Neocomian; but calcareous fragments of Wealden age are met with in Brandenburg. These, however, do not correspond with the Wealden strata of N.W. Germany, and their origin is unknown. Tertiary erratics are rare and of limited distribution, but fossil wood and amber are widely scattered in the Boulder-clay.

The direction in which the erratics have travelled is partly from North to South, and partly from North-east to South-west. There is no indication of any movement from N.W. to S.E., and no erratics from Norway are met with in the Boulder-clay of Germany. The author believes that the Boulder-clay has been distributed by floating ice, a view which is opposed to that held by the large majority of recent investigators of the subject, who maintain that it is due to the direct action of glacial or inland ice. G. J. H.

REPORTS AND PROCEEDINGS.

I.—Linnean Society of London.

November 5, 1885.—Sir John Lubbock, Bart., M.P., F.R.S., President, in the chair.

The first part of an exhaustive Monograph "On Recent Brachiopoda," accompanied by illustrations, by the late Dr. Thomas Davidson, F.R.S., etc., was read by the Secretary. In this the author reviews the labours of his predecessors in the same field, with regard to the shell, the anatomy of the adult animal, and its embryology. As regards the perplexing question of affinities, he remarks:—"Now, although I do not admit the Brachiopoda to be Worms, they, as well as the Mollusca and some other groups of Invertebrates, may have originally diverged from an ancestral vermiform stem, such as the remarkable worm-like mollusc, *Neomenia*, would denote." He lays stress on the Brachiopodous individual being the product of a single ovum, and not giving rise to others by gemmation. He considers that the shell,

the pallial lobes, the intestine, the nerves, and the atrial system afford characters amply sufficient to define the class. The greatest depth at which a living species has been found alive has been 2990 fathoms. As to classification, he groups the recent species into two great divisions: I. *Anthropomata* (Owen)=*Clistenterata* (King); II. *Lypomata* (Owen) = *Tretenterata* (King). The *Anthropomata* he divides into three families:—(1), *Terebratulacea*, with seven subfamilies and thirteen genera and subgenera, seventy species, and twenty-one uncertain species; (2), *Thecideidæ*, with one genus and two species; (3), *Rhynchonellidæ*, one genus, one subgenus, and eight species. The *Lypomata* he also divides into three families, five genera and subgenera, twenty-three species, and seven uncertain species:—(1), *Craniidæ*, with one genus and four species; (2), *Discinidæ*, with one genus, one subgenus, and eight species; (3), *Lingulidæ*, with one genus, one subgenus, and eleven species. He does not accept M. Deslongchamps' scheme (1884) of classifying the *Terebratulina*, bringing forward Mr. Dall's observations on *Waldheimia floridana* of delicate spiculæ in the floor of the great sinuses as telling evidence against the arrangement. The various genera and species are then dealt with, followed by remarks on the *Terebratulaceæ*, with copious descriptions and observations.

II.—Reading Literary and Scientific Society, Oct. 13, 1885.

"On the Coal-fields of the United Kingdom." Inaugural Address from the President, J. H. Blake, F.G.S., Associate Mining Institute C.E., of H. M. Geological Survey of England.

The President remarked that the question as to the rapid exhaustion or otherwise of our coal-fields was of national interest and importance. Coal consists of indurated or mineralized vegetable matter, and occurs in seams, interstratified in beds of sandstone, grit, shale, clay, and ironstone, and more rarely of limestone. These together are called the Coal-measures, which in some Coal-fields attain a thickness of some thousand feet. Of the amount of vegetation required to form not only one seam but forty or fifty or more, varying from one inch to several feet in thickness, which often succeed each other in Coal-fields, we can form no adequate conception, any more than we can calculate the time required for their growth and consolidation. Passing more or less through the stage of peat, each bed or mass of vegetation got buried under successive sediments, and through the influence of time, water, chemical changes and pressure eventually became converted into coal. In Britain and elsewhere the Carboniferous rocks, which were originally more or less horizontal, were disturbed and thrown into a series of wave-like curves or contortions together with other formations of older date. After this disturbance, combined with faults or dislocations of the beds, denudation or waste ensued, and the upper part of the curves being most exposed were in many instances removed or worn away, the portion so removed supplying material for newer strata. The lower part of the curves, or basin-shaped portions, were preserved from destruction by their

position. During and after this waste of Carboniferous rocks the Permian and other newer strata were deposited on the eroded edges of the Carboniferous and other older strata, and these in their turn also underwent disturbances in Britain in a minor degree followed by denudation. Thus the Permian and other newer strata lie unconformably on the Carboniferous and other older rocks. It is sometimes possible to estimate approximately and sometimes with certainty the area occupied by Coal-measures under the overlying Permian and Secondary formations, by giving attention to the "strike" and "dip" or inclination of the beds and by other means; and even to infer the basin-shaped form of a Coal-field, part of which is concealed. It was by paying careful attention to physical phenomena such as these and to details of stratification, the thickening and thinning of the formations, their conformity and unconformity, the occurrence of faults or dislocations and other disturbances, that the Committee appointed by the Royal Commission were enabled to estimate the amount of coal, namely, 56,273 millions of tons, which probably exists at workable depths under the Permian, New Red Sandstone and other superincumbent strata in the United Kingdom. Of these 56,273 millions of tons, upwards of 23,000 millions were estimated to occur under Yorkshire, and the remainder in varying proportions from 33 millions in one locality to upwards of 5000 millions in another, under Warwickshire, Leicestershire, Staffordshire, Denbighshire, Cheshire, Lancashire and a few other places in England, and 27 millions in Ireland. In estimating the quantity of available coal in the Coal-fields of the United Kingdom, the depth of 4000 feet was adopted by the Royal Commission as the limit of practical working, and all seams or beds of less than one foot in thickness were excluded from the returns. Having alluded at length to the description of the Coal-fields of the United Kingdom, showing approximately the probable quantity of available or workable coal they contain, the lecturer summed up the calculations as follows:—Wales 34,466 millions of tons, England 45,741 millions of tons, Scotland 9845 millions of tons, and Ireland 155 millions of tons, a grand total of 90,207 millions of tons. To this must be added the 56,273 millions of tons estimated to exist at workable depths under the Permian, New Red Sandstone and other superincumbent strata, making an aggregate of 146,480 millions of tons. From 1870 to 1884—fifteen years—nearly 2052 millions of tons have been produced in this kingdom. Mr. Godwin-Austen had shown that Coal-measures, which thin out under the Chalk near Therouanne, probably set in again near Calais, and are prolonged in the line of the Thames Valley, parallel with the North Downs, and, continuing thence under the valley of the Kennet, extend to the Bath and Bristol Coal area. He showed upon theoretical grounds that the Coal-measures of a large portion of England, France, and Belgium were once continuous, and that the present Coal-fields were merely fragments of the great original deposit preserved in hollows. These views, the lecturer continued, are supported by many eminent geologists who gave evidence before the Commission, but they did not receive the support

of Sir Roderick Murchison. The question of coal being deposited in the South of England is still a theory. Turning to the question of the duration of the total available quantity, the lecturer said that chiefly depended upon the statistics of consumption. In the year 1660 the coal produce of the United Kingdom was apparently only about $2\frac{1}{4}$ millions of tons; in 1700 a little more than $2\frac{1}{2}$ millions; in 1750 nearly 5 millions; in 1800 upwards of 10 millions of tons. About this period the system of canal navigation was rapidly extended, and the result was that coals were gradually finding their way into new districts, by which means the consumption of coal was greatly increased. In 1816 the production reached probably 27 millions. Advancing to a later period when coal statistics were more carefully collected, it appears that in 1854 the production of coal was upwards of 64 millions. From that period up to and including 1883, when the production of coal in the United Kingdom reached the largest quantity yet recorded, namely, nearly $163\frac{3}{4}$ millions of tons, there has been a progressive increase; except in the years 1857, 1858, 1874 and 1878, on which occasions there was a decrease varying from about one to two millions as compared with the quantity raised in the year immediately preceding these dates. Again last year (1884) there was a decrease of nearly three millions of tons. Whatever view may be taken of the question of the duration of coal, the results will be subject to contingencies. On the one hand, the rate of consumption may be thrown back to any extent by adverse causes affecting our national prosperity, and on the other hand, new discoveries and developments in new directions may arise to produce a contrary effect upon the consumption of coal. Every hypothesis must be speculative, but it is certain that if the present rate of increase in the consumption of coal be indefinitely continued even in an approximate degree, the progress towards the exhaustion of our coal will be very rapid.—From the *Reading Observer*, Oct. 17, 1885.

III.—Geological Society of London.

(1.)—Nov. 18, 1885.—Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "Results of Recent Researches in some Bone-caves in North Wales (Ffynnon Beuno and Cae Gwyn)." By Henry Hicks, M.D., F.R.S., F.G.S., with Notes on the Animal Remains, by W. Davies, Esq., F.G.S., of the British Museum (Natural History).

This paper contained the results of researches carried on in these caverns in the summers of 1883, 1884, and 1885 by Mr. E. Bouverie Luxmore, of St. Asaph, and the author. The enormous collection of bones belonging to the now extinct animals of Pleistocene age obtained had been submitted for examination to Mr. W. Davies, and afterwards distributed to various museums. Several well-worked flint implements were also discovered in association with the bones.

The following are the conclusions arrived at by the author, from the facts obtained during the explorations:—That abundant evidence has been furnished to show that the caverns had been occupied by hyænas, and possibly by other beasts of prey, as dens, into which

portions of carcasses of various animals had been conveyed in Pleistocene times. The very great abundance of some animals, such as the rhinoceros, horse and reindeer, and the frequent presence of bones belonging to young animals, proved that the plain of the Vale of Clwyd, with that extending northward under the Irish Sea, must have formed a favourite feeding-ground even at that time. The flint implements and worked bones showed also that man was contemporary with these animals. The facts perhaps, however, of greatest importance, made out during these researches, are those which bear on some questions of physical geology in regard to this area, which hitherto have been shrouded more or less in doubt. The views on the physical conditions in Pleistocene times of the areas in North Wales in which these and the other bone-caverns occur, so ably put forward by Sir A. C. Ramsay, appeared to the author to be strongly supported by the results obtained in these explorations. The ravine in which the caverns occur must have been scooped out previous to the deposition in it of the glacial sands and Boulder-clays. This sand and clay, there seems good evidence to show, must have filled up the ravine to a height above the entrances to the caverns, and such sands and clays are now found at some points to completely fill up the caverns. How, then, did these sands and clays get into the caverns? Were they forced in through the entrances by marine action or by a glacier filling the valley? Or were they conveyed in subsequent to the deposition of the Boulder-clay in the valley and surrounding area? The position of the caverns in an escarpment of limestone, at the end of a ridge of these rocks, with a sharp fall on either side, prohibits the idea that the material could have been washed in from the higher ground, as has been suggested by some in the case of other caverns, if it had anything like its present configuration. Moreover, there is scarcely any deposit now visible upon the limestone ridge, and there is no certainty that there ever was deposited there any great thickness of such a clay as that now found in the caverns. The general position also of the bones in some of the tunnels seems to indicate clearly that the force which broke up the stalagmite floor, in some places 10–12 inches thick, and stalactites 6 to 8 inches across, which thrust many of the large and heavy bones into fissures high up in the caverns and placed them at all angles in the deposit, and must have acted from the entrance inwards, and the only force which seems to meets these conditions is marine action. The following seem to the author to be the changes indicated by the deposits. The lowest in the caverns, consisting almost entirely of local materials, must have been introduced by a river which flowed in the valley at a very much higher level than does the little stream at present. Gradually, as the valley was being excavated, and the caverns were above the reach of floods, hyænas and other beasts of prey occupied them, and conveyed the remains of other animals into them. Man also must have been present at some part of this period. Gradually the land became depressed, the animals disappeared, stalagmite was formed, and the sea at last entered the caverns, filling them up with sand and pebbles, and burying also the remains not

washed out. Floating ice deposited in this sea the fragments of rocks derived from northern sources, and these became mixed with local rocks and clays brought down from surrounding areas. The greater part of the Boulder-clay in the Vale of Clwyd was probably deposited as the land was being raised out of this Mid-Glacial sea. During the process of elevation the caverns became again disturbed by marine action and the upper fine reddish loam and the laminated clays were deposited. It seemed to the author impossible to avoid the conclusion that these caverns must have been submerged, and afterwards elevated to their present height of about 400 feet above the level of the sea, since they were occupied by Palæolithic man and the Pleistocene animals.

2. "On the Occurrence of the Crocodilian Genus *Tomistoma* in the Miocene of the Maltese Islands." By R. Lydekker, Esq., F.G.S.

The author described the anterior portion of the cranial rostrum of a Crocodilian from the Miocene of Malta, to which Prof. Sir R. Owen has given the MS. name of *Melitosaurus champsoides*. The author considered that there were no characters by which the specimen could be generically distinguished from *Tomistoma*. Mention was made of a second crocodilian skull from the Miocene of the Maltese Islands, and of a third from Lower Austria, both of which the author thought might be included in the same genus.

3. "Description of the Cranium of a new Species of *Erinaceus* from the Upper Miocene of Œningen." By R. Lydekker, Esq., F.G.S.

The author described the palatal half of the cranium of a large species of *Erinaceus* from the Upper Miocene of Œningen, which he regarded as closely allied to the existing *E. europæus*, and proposed to name *E. œningensis*.

(2.)—Dec. 2, 1885.—Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "On some Borings in Kent.—A Contribution to the Deep-seated Geology of the London Basin." By W. Whitaker, B.A., F.G.S., Assoc. Inst. C.E. (Communicated by permission of the Director-General of the Geological Survey.)

Seven deep borings in the eastern part of Kent were described, all of them reaching to the Gault. The chief one is at Chatham Dockyard, where after passing through the whole thickness of the Chalk, the Gault was found to be 193 feet thick; whilst the Lower Greensand was only 41 feet, and was underlain by Oxford Clay, a formation not before known in Kent.

These facts involve the thinning of the Lower Greensand from 200 feet at the outcrop a few miles to the south, and the entire loss of the whole of the Wealden Series, which further south exists in great force, the Weald Clay being 600 feet thick, or perhaps more, and the Hastings Beds 700 feet or more.

Still further south, in the central part of the Wealden district, there are outcrops of the Purbeck Beds, whilst the Subwealden boring continues the series downwards. We have thus an addition

to the beds wanting at Chatham of some 400 feet of Purbeck and Portlandian, of over 1100 feet of Kimmeridgian, and of nearly 500 ft. of Corallian, etc. In a section of 32 miles, therefore (the distance between the Subwealden and the Chatham borings), we have a thinning of beds to the extent of over 3400 feet, or at the average rate of about 100 feet in a mile.

This northerly thinning agrees with the facts that have been brought before us from other deep borings in and near London; but the Chatham boring is the first in the London Basin in which a Middle Jurassic formation has been found. The teaching of the deep borings, as a whole, is that north of the Thames older rocks rise up beneath the Cretaceous beds, whilst on the south newer rocks come in between the two.

The question of the finding of the Coal-measures beneath parts of the London Basin seems to admit of a hopeful answer, whilst the lesson of the deep borings as regards water-supply is that there is small chance of getting water from the Lower Greensand at great depths underground.

It would be well if underground exploration could be conducted on a systematic plan, with proper regard to both topographical and geological considerations, and not left any longer to the chance work of people in search of water.

2. "Note on some recent openings in the Liassic and Oolitic Rocks of Fawler in Oxfordshire, and on the arrangement of those rocks near Charlbury." By F. A. Bather, Esq. (Communicated by Prof. J. Prestwich, M.A., F.R.S., F.G.S.)

The river Evenlode rises in the Lower Lias of the Vale of Moreton, traverses the range of Oolites, and joins the Isis opposite Wytham Mill. Lias is exposed to about three-quarters of a mile below Fawler, where Great Oolite is brought down by a fault; and in the Geological Survey map Lower Lias is brought down the valley to within half a mile of Charlbury Railway Station.

In this paper the author gives reasons for believing that the distribution of the different beds constituting the Lias in the Evenlode Valley do not agree with the Geological Survey map, nor with Prof. Hull's description, recent sections and borings made for clay, used in brick- and pottery-making, having exposed Lower-Lias clay in a brick-yard at Fawler, marlstone and Upper-Lias clay in a neighbouring coombe, and in a long section 100 yards north of the brick-yard Inferior Oolite comes in upon the Upper-Lias clay. On examining the banks of the Evenlode north of Charlbury, it was found that clays referred to in the Survey map to Lower Lias are really Upper Liassic, being above the Marlstone, sections of which are exposed near Culsham Bridge.

It was shown how these corrections in the mapping of the ground are explained by the section along the line of the Evenlode and by the dips of the beds.

CORRESPONDENCE.

OLD RED SANDSTONE UNDER LONDON.

Sir,—In his paper "On the Nature and Relations of the Jurassic Deposits which Underlie London" (Quart. Journ. Geol. Soc. vol. xl.) Prof. Judd discusses the age of certain red rocks met with deep down at Richmond, Crossness, and at Kentish Town. One question that arose was whether rocks of the barren Old Red Sandstone type and of the Devonian (Eifelian) type were likely to be met with in close proximity. While admitting that, as in the Ardennes, so under London, the lowest member of the Devonian (the Gédinnien of Belgian geologists) may underlie strata of the Eifelian type; yet Prof. Judd attaches much weight to the suggestion made by Mr. Whitaker that rocks of Old Red Sandstone and Devonian type are not likely to occur near together.

This suggestion is, however, opposed to what is well known in Devonshire. There we have the Red Sandstones of Cockington near Torquay, and the grits of Picklecombe and Staddon near Plymouth, as well as the Pickwell Down Sandstones of North Devon, which, as Mr. Champernowne remarks (Proc. Geol. Assoc. vol. viii. p. 469), probably represent (both stratigraphically and lithologically) parts of the Upper Old Red Sandstone. These strata are nowhere far removed, geographically, from rocks of the Eifelian type.

Then, too, we have the Lower Devonian grits of Lincombe, Warberry and Meadfoot in South Devon, possibly equivalent in part to the Hangman grits of North Devon; but they are of a different character from the rocks resembling the Upper Old Red Sandstone. Prof. Prestwich has insisted on the resemblance of the Kentish Town red beds to the (Upper) Old Red Sandstone of the Mendip Hills (Judd, *op. cit.* p. 753).

Hence, without committing myself to any definite opinion on the subject, there appears to me no reason why rocks of Old Red Sandstone type (whether Upper or Lower) should not occur, as well as Devonian strata, under the London Basin. Recent researches, moreover, tend to show that the Devonian (Eifelian) strata may bridge over the interval between the Upper and Lower Old Red Sandstone.

Of course it is still open to question whether these red rocks under London are Upper or Lower Old Red Sandstone, or New Red Sandstone (Poikilitic).

Horace B. Woodward.

Bradford-on-Avon, *Nov.* 1885.

THE "FAUNA ANTIQUA SIVALENSIS."

Sir,—As your readers are doubtless aware, the atlas of Falconer and Cautley's "Fauna Antiqua Sivalensis" was originally published in separate parts, with paper covers bearing the date of publication of each part; but as the work was never completed, no general title-page ever appeared. In all copies in public libraries that I have seen the atlas has been bound, and the original paper covers destroyed, so that there is no means of knowing the date of publica-

tion of particular plates in which specific names make their first appearance, and I have noticed in several instances that writers have consequently been unable to give the exact date of publication to such names. As I am fortunate enough to possess a copy in which the original covers are preserved, I have thought it well to record the dates of publication of the different parts, and the numbers of the plates contained in each, viz.—

1846. Part I. Plates 1—12.
,, ,, II. ,, 13—22 and 13 *a* (double).
1847. ,, III. ,, 12 A, 12 B, 12 C, 12 D, 14 A, 14 B, 18 A, 19 A, 20 A, 23, 24, 24 A.
,, ,, IV. ,, 25—33, and 25 A, 29 A.
,, ,, V. ,, 34—45.
,, ,, VI. ,, 46—56.
,, ,, VII. ,, 57—68.
,, ,, VIII. ,, 69—80.
1849. ,, IX. ,, 81—92.

The Lodge, Harpenden, Herts. R. Lydekker.

FAUNA OF THE GAS-COAL OF BOHEMIA.

Sir,—In the Geological Magazine for November, 1885, p. 527, Prof. E. D. Cope, in a very kind mention of my work, "Fauna der Gaskohle in d. Kalksteinen d. Permformation Böhmens," Prag, 1885, asks why I do not agree with him that *Cricotus* had the thoracic vertebræ embolomerous. Having only had the opportunity of comparing the figure of *Cricotus*, which I have reproduced on p. 4, band ii. heft i., I saw only the neural arches and the ribs, and on the lumbar vertebræ some bodies which I was inclined to consider elements of rachitomous structure. I feel sure that in the rich material in Prof. Cope's hands he has evidence in support of his opinion that all the vertebræ in *Cricotus* are embolomerous in structure.

Prague, 3 *Nov.*, 1885. Dr. Anton Fritsch.

ON SOME CRETACEOUS MADREPORARIA, BY MR. R. F. TOMES, F.G.S.

Sir,—As Referee of the paper by Mr. R. F. Tomes 'On some imperfectly known Madreporaria from the Cretaceous Formation of England,' which was withdrawn by the Author from the Geological Society, and is printed in the Geological Magazine for December, 1885, p. 541, Pl. XIV. I take exception to the statement in brackets in the concluding paragraph of the paper on p. 552, "It is now printed verbatim with figures by Mr. C. Berjeau of the specimens exhibited at that meeting," as calculated to mislead. It is true that the originals of *some* of the figures on the Plate accompanying the paper were exhibited at the Meeting, but the original specimens of Figs. 1, 2, 3, 4, 5, 6, were not shown on that occasion. Further, in the Explanation of the Plate on p. 552, it is stated: "Fig. 7. *Rhizangia mamilliformis.* Three corallites united by the stolon." Fig. 8. *Ib.* Two corallites similarly united." In the originals, however,

which were exhibited at the Meeting, the corallites were *not* united by the stolon, and they are not figured as united (in Plate XIV. Figs. 7, 8) in the GEOLOGICAL MAGAZINE, though they were so in the original drawing submitted to the Geological Society by Mr. Tomes.

As these statements relate to matters of fact, I should feel obliged if you would allow me this opportunity of rectifiying them in the MAGAZINE.

"THE REFEREE."

MISCELLANEOUS.

THE "COMING-OF-AGE" OF THE GEOLOGICAL MAGAZINE.

TESTIMONIAL TO THE EDITOR, DR. H. WOODWARD, F.R.S., F.G.S.

A meeting of the Subscribers to the Testimonial to Dr. H. Woodward, F.R.S., for twenty-one years Editor of the GEOLOGICAL MAGAZINE, was held on the 15th December, 1885, at the Apartments of the Geological Society, Burlington House, when Prof. T. G. Bonney, F.R.S. (President Geol. Soc.), presented to that gentleman, on behalf of the subscribers, a silver salver with a tea and coffee service and a cheque for £253. On making the presentation, Prof. Bonney addressed Dr. Woodward as follows:—

"DR. WOODWARD—

It is now rather more than twenty-one years since the GEOLOGICAL MAGAZINE arose upon the foundation—I had almost said the ruins—of an earlier publication. For the whole of that time you have been one of its editors, for almost the whole its principal editor. On you, though supported by the aid and counsel of most able coadjutors, has fallen the chief burden of the work, the chief responsibility of the undertaking.

It would be difficult to appreciate too highly the aid which the GEOLOGICAL MAGAZINE has rendered to the progress of our Science. It has supplied a want which had long been felt, which would at once recur if it ceased to make its welcome monthly appearance. There are many Geological notes and papers written, which, from their brevity, from their interest being of a somewhat ephemeral character, from their treatment being more historical or their aim more controversial, are not exactly suited to the pages of the Quarterly Journal of the Society in whose rooms we are assembled; yet the appearance of these in print is a boon to students and a benefit to science. The GEOLOGICAL MAGAZINE thus occupies a position, which, on one hand, has common ground with our Quarterly Journal; on another, with the Proceedings of Local Scientific Societies; on a third with such a publication as "Nature," but which is not exactly covered by any one of these. During all ese years it has been an important aid to British Geologists, and

I do but echo their sentiments when I wish it and its editor a long and prosperous life.

But this, Dr. Woodward, is not the only service that you have rendered to science. It is possible for an editor to nip early aspirations in the bud and to petrify the neophyte in science by a cold breath of disapproval or sarcasm. All, however, who, like myself, have made in the pages of the GEOLOGICAL MAGAZINE their first venture in scientific authorship, will be ready to testify to the kind welcome and friendly encouragement which we received from you. Many, I feel sure, have thus been animated to further efforts; so that you may with just pride assert that under your auspices the GEOLOGICAL MAGAZINE has enlisted many recruits for the great army of scientific workers. Yet more, not only in its pages, but also at your place in the British Museum, you have been ever ready to help the student, and to place at his disposal, with unvarying kindness and courtesy, the full stores of your ripe knowledge. This work, so far as the GEOLOGICAL MAGAZINE is concerned, you have done, in reality, if not in name, at your own cost. The small sum assigned to you as Editor—inadequate at the best as a return for your labours, has frequently been consumed by expenses which you have incurred to increase—I had almost said to maintain—its efficiency. In this wealthy country those who labour on behalf of science, especially in regard to its literature, must generally be content to do it at their own cost. You have done this ungrudgingly for so long a time, though, as the chief bread-winner of a family, you might justly have excused yourself from so unremunerative a task.

The sum of money which, on behalf of the Subscribers, I have the pleasure of placing in your hands is no discharge of the debt which is due to you from Geologists, but it may suffice to prevent you from feeling that the members of your household have been serious losers by your zeal for the progress of Science; and in asking you to accept this small present of plate, your friends, for whom I speak, wish to leave with you a more visible memorial of their respect and regard. They trust it will remind yourself and the helpmate who has shared your labours—remind you both, we trust, for many years to come—that we were not wholly ungrateful. But, even when the call to cease from work has sounded for those chiefly interested in the friendly gathering of to-day, this little memorial may avail to show your children how much their father was esteemed, and may nerve them to emulate the example of their parents."

Dr. Woodward in reply said:—

"PROF. BONNEY AND GENTLEMEN—

Words are but feeble vehicles in which to convey the warm feelings that rise in my mind to-day, and strive for utterance in response to the eloquent eulogium you have just delivered; and when I look at the munificent testimonial you have presented to me, I am at a loss to conceive how my poor exertions as Editor of the GEOLOGICAL MAGAZINE can have been deemed worthy of so high a recognition.

Of one thing I feel assured that I owe very much to the kind words which you,

Sir, expressed from this chair in reference to myself in your Presidential address in February last, and I am grateful to learn how large a number of my friends have inscribed their names to this very handsome gift, which will be to me a lasting token of their regard and friendship, and for my children after me.

The GEOLOGICAL MAGAZINE is not by any means the earliest periodical specially devoted to geology, although it may very justly claim to have survived for a longer period than either of its predecessors.

The first attempt was made by Mr. Edward Charlesworth, F.G.S., who commenced "The London Geological Journal" in September, 1846. Three very excellent and richly illustrated Numbers appeared in September, 1846, and February and May, 1847, when it expired – probably from want of funds. The veteran Editor still survives, and so also do three of his contributors, Prof. Morris, Mr. James Carter of Cambridge, and Mr. William Cunnington, F.G.S., formerly of Devizes, Wilts.

The "Geologist," edited by Mr. S. J. Mackie, was commenced in 1858, and after five years and a half was merged (by purchase) in the GEOLOGICAL MAGAZINE in July, 1864.

It is pleasant to observe amongst the contributors to the *first* volume of the "Geologist" in 1858, the names of the Rev. P. B. Brodie, Prof. J. Morris, Prof. Rupert Jones, Prof. (Sir) A. C. Ramsay, and Prof. Prestwich, names still prominent on the "roll-call" of eminent *living* geologists.

It is gratifying to know that for the past 21 years I have carried with me so large and influential a body of supporters, both at home and abroad.

But of the friends who stood beside us at the outset of our enterprise, many have, alas! left us and "gone with the great departed into the Silent Land."

I rejoice, however, that Sir Richard Owen, Sir A. C. Ramsay, Dr. A. Geikie, Professors Huxley, Prestwich, Rupert Jones, Morris, Boyd Dawkins, Ruskin, Edward Hull, H. G. Seeley, Bonney, Nicholson, Dr. John Evans, Mr. Etheridge, Mr. Topley, Mr. H. M. Jenkins, Mr. Kinahan, Mr. Meyer and many others amongst my first contributors, are still with us; nor have we lacked very many new and able friends who have helped us through what may be termed the "renaissance period," or middle-age of our existence, and have continued to stand by us manfully until the present day.

Glancing for a moment at the period embraced by the joint volumes of the "Geologist" and the GEOLOGICAL MAGAZINE combined (*i.e.* 28 years), we have witnessed in that quarter of a century some of the greatest advances which have ever been made in our science.

The dissemination of the Darwinian theory of Evolution has made the long-buried past of Geological history only an early chapter in the life of our earth, and Palæontology and Zoology have clasped hands never to be again disassociated.

The past quarter-century has also revealed to us that wonderful chapter in the History of Early Man as displayed in the Old River Valley Gravels, Brickearths, and Peat Deposits, in the Bone-caves, Rock-shelters, Kitchen-middens, Lake-dwellings, and other Quaternary records of our Race, bringing into prominence the latest chapter of Geology which 'dovetails' the 'prehistoric' with the 'historic' periods.

The time would fail to tell of the progress of our science in a better knowledge of Physiography, of "Climate and Time," the "Great Ice-Age," the Study of Earthquakes and Volcanoes; the Depths of the Sea; the Formation of Mountain Chains; of Metamorphism; Atmospheric Denudation; of the Continuity of Matter. Lastly, but most important, both for organic and inorganic studies, has been the grand development of Microscopic research as applied both to Palæontological and Mineralogical studies, with which the names of our past President H. C. Sorby, and our

present President Prof. Bonney, will always be associated, and for which the Royal Microscopical Society and Mr. Frank Crisp have laboured energetically and long.

Probably no better sign of the utility of the GEOLOGICAL MAGAZINE could be given than the fact of the abundant supply of materials to fill its pages which the Editor receives.

Having started the present serial in 1864, it is very agreeable to be able to state that after the first year, during which my friend Prof. Rupert Jones undertook (at Messrs. Longmans' request) the task of Chief Editor—I have had the sole charge of the GEOLOGICAL MAGAZINE and have passed each number through the press myself, nor have I relegated the duty to other hands on a single occasion.

Like other ephemerides, the GEOLOGICAL MAGAZINE has had its periods of financial depression. At 18 months it was given over for dead by its first publishers (Messrs. Longmans & Co.), and again at 10 years old it hardly seemed likely to pull through, and Messrs. Trübner & Co. were rather doubtful as to the advisability of letting it go on; but thanks to the generous support of friends, it recovered from both crises and has still, I trust, the promise of many years of usefulness before it.

Having arranged its contents month by month for so many years, with my own hands, I have sometimes imagined it to be all my own; but it would indeed be a miserable failure were it not for the long list of distinguished contributors whose papers give value to its pages, and without whom the GEOLOGICAL MAGAZINE would years ago have ceased to exist.

As regards its financial position, the GEOLOGICAL MAGAZINE has the disadvantage of being a Class-periodical — appealing only to Geologists, Palæontologists, and Mineralogists.

The "Annals and Magazine" and "Silliman's Journal" have much broader bases, taking cognizance of all branches of Natural History, and, in the case of Silliman, of Chemistry and Astronomy also.

But notwithstanding our limited sphere, we have been able to sustain life for 21 years, and *a few degrees of warmth* on the part of our geological friends, in adding to our list of subscribers, would produce a marvellous effect in an *increased circulation*, gratifying alike to Publishers, Printers, Artists and Editor, who have done their best to keep the production of the GEOLOGICAL MAGAZINE up to the standard of the present time.

If any stimulus were needed by myself as Editor, my friends have this day applied it in the form of a very substantial recognition of my services, for which I am bound to reiterate my warmest and most sincere thanks. I trust, Sir, that you will long continue, with my other friends, to give me that kindly aid and support which is so essential to the future success of the GEOLOGICAL MAGAZINE.

WORK ON BRITISH PETROGRAPHY.—Messrs. Watson Bros. and Douglas, of Birmingham, announce the publication of a work on British Petrography, being a Description of the Ordinary Rocks of the British Isles, by J. J. Harris Teall, M.A., F.G.S., etc., illustrated by 50 Chromo-Lithographic plates from original drawings of typical microscopic slides. To be completed in 25 Imperial Octavo Monthly parts, including 100 figures and about 350 pages of text. The first part is announced to be published in February next. From a previous acquaintance with Mr. Teall's able and careful labours in petrography, we anticipate that this work will be a most valuable Book of Reference for the use of [illegible]essors and Lecturers in Geology and Petrography, and for all who are interested [illegible] the study of British Rocks.

Skeleton of *Phenacodus primævus*, Cope,
[illegible] N. America.